SCIENCE

FRIDAY, APRIL 2, 1915

CONTENTS

MSS. intended for publication and books, etc., intended for review should be sent to Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

MYCOLOGY IN RELATION TO PHYTOPATHOLOGY[1]

IN preparing a presidential address one has always to meet and answer the same old question that has confronted presidents and retiring presidents of societies ever since presidents and presidential addresses were invented, *i. e.,* Should the effort be primarily to entertain and amuse, or to instruct? I fear that any effort of mine to entertain would be a grievous failure, while an effort to instruct may be but little more successful. Since of two evils we are advised to choose the lesser, I have decided to attempt something more in the line of instruction than entertainment. Instruction is usually regarded, I believe, as a more or less normal function of a specialist, and as modern social and economic conditions have compelled specialization, we must accept the consequence.

The subject of plant pathology properly includes all the phenomena connected with abnormal forms and functions of plants. These abnormal conditions may be grouped in three classes, according to their origin: First, those which are of non-parasitic origin; second, those which are caused by plant parasites; third, those which are caused by animals. Excluding from present consideration diseases directly due to animals, we have left the two classes, non-parasitic and parasitic. By far the greater part of the trouble with which the phytopathologist has to deal are caused by plant parasites. In fact, the greater part of the phytopathology of to-day might quite properly be designated parasitology, and

[1] Address of the retiring president of the Botanical Society of Washington, March 2, 1915.

parasitology is of course only a branch of mycology.

Plant pathology is a subject of very recent development and can scarcely be said to have existed before the middle of the last century. During the period from 1830 to 1850 attention began to be given to this subject. Unger, Wiegmann, Meyen, Raspail and Regel wrote on the diseases of plants. These authors took up the subject from the standpoint of general botany and human pathology rather than mycology. Some very curious ideas prevailed; *e. g.*, it was believed that fungi such as rusts were produced by the puncture of insects (Raspail, 1846). Unger's idea was that certain fungi were outgrowths or modifications of the tissues of the diseased plant. These and earlier works contained various more or less academic discussions of various diseases, based largely upon erroneous ideas of the structure and nature of the parasite as well as the host. As an illustration of how persistent medieval ideas and conceptions are I may cite a recent instance. A correspondent, in explaining the cause of a strawberry disease, states that it is due to "elemental debasement." This reminds one of the "original sin" of the old theology, to which it may perhaps be closely akin.

Under the influence of the important contributions to the knowledge of the cellular structure and tissues of plants, which were made during this period, together with the work of contemporary mycologists, the foundation was laid for a more rational and correct interpretation of plant diseases and parasites.

Since the great majority of plant diseases are caused by fungi, it is quite proper that mycology should be considered the chief cornerstone of this branch of science and should be thoroughly understood by the plant pathologist.

In order to get a proper conception of any subject and to understand and appreciate its present condition and needs, a knowledge of its past history and development is necessary. It is quite appropriate that Florence, the chief seat of learning and the leader in literature, religion, art and science during the Renaissance and beginning of the modern era, with the illustrious names of Dante, Savonarola, Raphael and Michael Angelo should have produced the great botanist, Micheli, who may be justly considered the father of mycology. His great work, "Nova Plantarum Genera," published in 1729, was devoted largely to the description and illustration of fungi. This work remained unsurpassed for fifty years and is still recognized as a classic on this subject. Micheli's collections of fungi are still preserved in Florence beside those of Cesalpini. Some of his specimens compare favorably with those of much more recent mycologists.

Following Micheli some twenty-five years later came Battara, also an Italian. During the latter half of the eighteenth century Tode, Hoffman, Batsch, Bulliard and Persoon made important contributions to descriptive mycology. In the early part of the nineteenth century the most distinguished students of the subject were Persoon, Greville, Wallroth, Link, Sowerby, Fries and Corda in Europe, while in America the illustrious Schweinitz laid the foundations of American mycology and took rank among the first mycologists of the world. Following him in this country came Curtis, Ravenel, Peck, Ellis, Farlow and Burrill. Most of the work of the early writers was systematic, and may appear to some of us to be very crude and unsatisfactory, but when we consider the conditions under which they labored and the tools and technique available, it will be found that their work is of as high quality

as could be expected; and is perhaps no more imperfect than ours will appear to mycologists and pathologists a century hence.

Beginning about 1850, there was a great change and improvement in methods and aims in mycological work. The two most conspicuous men of this period were De Bary and Tulasne, who understood a careful comparative study of all that was known of the morphology and physiology of fungi, as well as original investigations of the life histories of the organisms. At the same time Berkeley in England, while devoting his time chiefly to descriptive work, gave much attention to the pathological aspects of the subject and published a very important series of papers in the *Gardener's Chronicle* (1854) on "Vegetable Pathology." In this connection, M. C. Cooke, who has recently passed away, should be mentioned. In America Farlow, Bessey and Burrill first introduced laboratory methods of studying fungi, taking up the work along the lines indicated by De Bary and Tulasne.

NOMENCLATURE

In considering the various phases of mycology in their relation to plant pathology, the subject of nomenclature deserves mention. The plant pathologist as well as the mycologist must use plant names. It is therefore important that this matter should be given careful consideration, in order to devise means of securing as nearly as possible uniformity and stability of usage. Unfortunately at present there is no generally accepted method of accomplishing these ends. It is therefore desirable that pathologists take an active interest in this subject and assist in determining what the fundamental requirements are to secure uniformity and stability and exercise their influence to secure the general adoption of such regulations. One of the subjects of most fundamental importance in this connection is that of types. It does not seem possible to secure any great degree of uniformity in the use of names until generic and specific names are fixed to definite types. Teachers of mycology and pathologists should consider these matters in a scientific spirit and without reference to personal preference or professional affiliations.

Closely related to this subject is that of terminology in general. There is at present a decided lack of accuracy and uniformity in the use of the various technical terms used in mycology and pathology. With the exception of the rusts, the descriptive terms used have not been accurately defined and coordinated in accordance with our present knowledge; *e. g.*, the term conidium is variously applied to spores produced either on external sporophores or within pycnidia. There is also lack of general agreement and uniformity in regard to the names applied to the various conidial and pycnidial forms of the Ascomycetes. We have such terms as stylospore, spermatium, micro- and macro-pycnospore, micro- and macro-conidium variously applied by different writers.

Of great importance also to the pathologist is the standardizing of methods and technique as far as possible. Though absolute standards in these matters can not well be attained, effort should be made to approximate definite standards as closely as possible.

TAXONOMY

Mycology formerly consisted chiefly of the identification of old species and the describing of so-called new species. This of course was natural and necessary, as there was a vast unknown group of organisms most of which had not been named or described. Unfortunately, the overwhelm-

ing number of the species and the few workers made it impossible for them to devote the time and study to the organisms necessary for satisfactory segregation and description. Species were usually based upon supposed host relations, slight morphological differences or geographical distribution. More recent and thorough studies have shown that these can not be generally depended upon. While one species of a genus may have very definite host relations, the next one may be very indefinite in this respect. In the same way morphological characters which are reliable in one genus or species may be very variable and unreliable in another. The same may be said of geographical distribution. Some species are apparently more or less cosmopolitan, while others are confined to rather limited geographical areas. These facts can only be determined by the most thorough monographic study of each genus or group. Our studies of *Endothia* have brought out these points with great clearness and emphasis. For instance, one of our American species, *E. gyrosa,* extends from the Atlantic coast to the Pacific, and from Connecticut and Michigan to Florida and Texas, whereas its near relative, *E. radicalis,* is restricted to the Appalachian region in America. Such facts are of exceeding importance to the pathologist in determining the nature and possibilities of a parasite.

LIFE HISTORIES

Of still greater importance to pathology, however, is a knowledge of the life histories of parasites. This subject is not only of exceeding importance to pathology, but also to phylogeny and taxonomy in general, and has important bearings on all other branches of mycology. The work of Tulasne and De Bary and their contemporaries was the first important contribution to this subject. Following the discovery of the pleomorphy of the Ascomycetes there was a tendency on the part of some mycologists to connect up all the various known forms of the so-called Fungi Imperfecti upon the basis of association, similarity or other more or less uncertain evidence. One of the most striking cases of this is furnished by Fuckel in his "Symbolæ Mycologicæ," 1869, where supposed pycnidial or conidial forms are given for the majority of the Ascomycetes listed. In some cases the author was probably correct, but none can be accepted without being verified by cultural studies or other reliable methods. The work of Tulasne, while much more reliable and satisfactory, was based primarily upon the intimate association or union in the same stroma of the different forms of fructification. Much of his work has already been verified by later investigators. Brefeld in his great work on the life histories of the fungi made an exceedingly important contribution to this subject. Unfortunately, many of the conidial and pycnidial forms which he obtained in culture from ascospores can not be identified and connected with certainty with forms already described.

It has already been thoroughly demonstrated that some of the Pyrenomycetes have from one to three metagenetic spore forms besides ascospores; *e. g., Sphærella, Glomerella, Guignardia, Plowrightia,* etc. It is also well known that some of the stages of a fungus may be parasitic and others apparently saprophytic; *e. g.,* many Pyrenomycetes mature their perithecia upon dead vegetable matter, while their pycnidial or conidial forms may be actively parasitic. This has led to the classification of most of the Pyrenomycetes, whose life histories are not known, as saprophytes. It is clear, therefore, that to even be able to classify an organism satisfactorily as a

parasite or saprophyte its life history must be known.

Here is a vast field for investigation which offers great opportunities for making valuable contributions to knowledge. Thousands of pleomorphic species whose life histories are unknown await the patient and properly equipped investigator. Present culture methods must be improved and new methods probably devised in order to induce many of these fungi to pass through their complete life cycles. It is in this field that we may expect very important discoveries in regard to the factors which determine the production of any particular spore form in the life cycle of a fungus. Of such factors we have very little definite knowledge at present.

PARASITISM

The exact nature of parasitism, its origin and modifications, is naturally of the utmost significance to pathology. This problem can perhaps be attacked with the greatest promise of successful solution in those cases which appear to be near the border line between saprophytic and the parasitic species. If we admit that evolutionary processes are still active, there seems no reason to doubt that parasites are at present in process of evolution. Whether this evolution is brought about by mutation or by a gradual accumulation of slight variations or by some other process or complex of processes not yet discovered, it would seem possible to get further light on this subject by a thorough investigation and comparison of some of the active parasitic Ascomycetes and their near relatives which seem to be saprophytic or only very weakly parasitic. A striking example of this condition of affairs is presented by the genus *Endothia* already referred to. *Endothia parasitica* is a most virulent parasite, whereas its near relative, *E. radicalis*, which occurs on the same host, shows little or no parasitic tendencies, while some of the other species show slight indications of parasitism.

ECOLOGY

In this connection it may be well to call attention to the great possibilities in the study of the ecology of the fungi. At present, unfortunately, there is little exact knowledge of the distribution and environmental relations of fungi. The exact limits of distribution of but very few species is known, and in fact the exact identity of many species is still doubtful. The question of their host relations is also not well understood except in the case of the rusts, smuts and powdery mildews. Our studies of *Endothia* appear to indicate that, in this group at least, the species have very definite geographical ranges which are not determined by their host relations, but apparently are very intimately associated with climatic and other environmental conditions, as well as competition with other fungi. All these things are of vital interest to the pathologist, especially in connection with the possibilities in the way of the spread of any particular parasite, or in determining the probable behavior of any foreign species which might be introduced. To know what fungi exist in any region and what their natural distribution and host relations are, is of the utmost importance in devising ways and means to prevent their introduction into other countries. In this connection I may quote from Winthrop Sargent in the Final Report of the Pennsylvania Chestnut Tree Blight Commission, 1914, page 12, as he presents the case in a very plain and forceful manner:

> In conclusion, it seems necessary to call sharp attention to the real lesson to be learned from the chestnut blight epidemic—viz.: the necessity of more scientific research upon problems of this

character; to be undertaken early enough to be of some value in comprehending, if not controlling the situation. We have seen that the blight might have been kept out of the country in the first place by inspection, or, once in, that it might have been destroyed, or at least checked, before it had gotten widely distributed. But instead it was permitted to enter, and to spread for many years without scientific notice, and for several more years without any organized attempt to control it, or even to study it seriously. Are we doing any better now with reference to the future?

GENETICS

While perhaps not having the same direct bearing upon pathological problems, still it may be worth pointing out that fungi appear to offer one of the simplest and easiest points of attack on the general problems of evolution, such as mutation, variation, and inheritance; in fact, the various problems of genetics. Here we have organisms comparatively simple in structure, either asexual or at least not complicated by possible hybridization and capable of rapid reproduction and cultivation under controlled conditions.

Coming finally to questions of prevention and control of diseases caused by parasites, it is only stating a truism to say that whatever success may be attained in this direction must depend chiefly upon the completeness of our knowledge of the parasite in all its aspects and relations.

Finally, mycologists, pathologists and all real scientists are searchers after truth. This implies not only large opportunities, but also obligations. "Noblesse oblige" is particularly applicable to the scientist. In these days of storm and stress it is, if possible, more important than ever that we should live up to the highest ideals of truth, and make individual and united effort to establish the universal reign of justice, peace, and brotherly love among mankind.

An excellent example of what the scientist should strive to be in all his human relations has been given us by Professor Charles E. Bessey, the distinguished botanist and beloved teacher, whom death has so lately taken from us. He not only sought truth and taught truth, but lived it, making the world not only wiser and richer, but better. May we all leave as noble a record when called to lay life's burdens down.

C. L. Shear

EDWARD WESTON'S INVENTIONS

The pioneer work of Dr. Edward Weston is not easy to describe in a few words. His restless inventive activity has been spread over so many subjects, has intertwined so many interlocking problems, that in order to understand its full value, it would be necessary to enter into the intimate study of the various obstacles which opposed themselves to the development of several leading industries which he helped to create: the electro-deposition of metals, the electrolytic refining of copper, the construction of electric generators and motors, the electric illumination by arc- and by incandescent-light, and the manufacture of electrical measuring instruments. An impressive list of subjects, but in every one of these branches of industry, Weston was a leader, and it was only after he had shown the way in an unmistakable manner, that the art was able to make further progress and develop to its present-day magnitude.

But why was Weston able to overcome difficulties which seemed almost unsurmountable to his predecessors and coworkers in the art?

The answer is simple: He introduced in most of his physical problems a chemical point of view—a chemical point of view of his own; a point of view which was not satisfied with general statements, but which went to the bottom of things. He did not

get his chemistry wholesale as it is dispensed in some of our hot-bed-method educational institutions. He had to get at his facts piecemeal, one by one, adjust them, ponder over them—collect his facts with much effort and discrimination; he did not acquire his knowledge merely to pass examinations, but to use it for accumulating further knowledge.

It seems rather fortunate for him that one of the first employments he got in New York was with a chemical concern which made photographic chemicals. This was the time of the wet-plate, when photographers made their own collodion, their own silver bath, their own paper. Whoever went through those delicate operations knew the difficulties, the uncertainties which were caused by small variations in the composition of chemicals or in the way of using them. Photochemistry is excellent experience for any young chemist who is disposed to generalize too much all chemical reactions by mere chemical equations. Whoever has to deal with those delicate chemical phenomena, which occur in the photographic image, knows that many unforeseen facts can not easily be accounted for by our self-satisfying but often superficial generalizations of the text-books.

Weston's tendency to observe small details in chemical or physical phenomena led him to improve the art of nickel-plating and electrolytic deposition of metals to a point where it entered a new era. When he undertook the study of the difficulties in this art, he took nothing for granted, but by close observation he succeeded in devising methods not only of improving the physical texture of the deposit, but for increasing enormously the speed and regularity with which the operations could be carried out; all these improvements are now embodied in the art of electro-typing, nickel-, gold- and silver-plating.

At this time, attempts had already been made for the commercial refining of copper by means of the electric current. But this subject was then in its first clumsy period, far removed from the importance it has attained now amongst modern American industries. Here again, Weston brought order and method, where chaos reigned. His careful laboratory observations, harnessed by his keen reasoning intellect, established the true principles on which economic, industrial, electrolytic-copper-refining could be carried out. Professor James Douglass[1] referred to this fact in a recent address:

> I suppose I may claim the merit of making in this country the first electrolytic copper by the ton, but the merit is really due him (Weston) who in this and innumerable other instances, has concealed his interested work for his favorite science and pursuits under a thick veil of modesty and generosity.

The whole problem of electrolytic refining, when Weston took it up, was hampered by many wrong conceptions. One of them was that a given horsepower could only deposit a maximum weight of copper regardless of cathode- or anode-surface. This fallacious opinion was considered almost an axiom until Weston showed clearly the way of increasing the amount of copper deposited per electrical horsepower, by increasing the number and size of vats and their electrodes, connecting his vats in a combination of series and multiple, the only limit to this arrangement being the added interest of capital and depreciation on the increased cost of more vats and anodes, in relation to the cost of horsepower for driving the dynamos.

The electro-deposition of metals forced Weston into the study of the construction of dynamos. Until then, the electric cur-

[1] Commencement address, Colorado School of Mines, *Metallurgical and Chemical Engineering*, Vol. XI., No. 7, July, 1913, page 377.

rent used for nickel-, silver- and gold-plating, as well as for electro-typing, was obtained from chemical batteries. Weston says that it was almost a hopeless task to wean electroplaters from these cells to which they had become tied by long experience and on the more or less skillful use of which they based many of the secrets of their trade.

If the dynamo as a cheap and reliable source of electric current was advantageous for nickel-plating, it became an absolutely indispensable factor for electrolytic copper refining. At that time, the dynamo was still at its very beginning—some sort of an electrical curiosity. It had been invented many years before by a Norwegian, Soren Hyjorth, who filed his first British patent as far back as 1855. Similar machines had been built both in Europe and America, but little or no improvement was made until Weston, in his own thorough way, undertook the careful study of the various factors relating to dynamo efficiency.

In 1876, Weston filed his first United States patent on rational dynamo construction, which was soon followed by many others, and before long he had inaugurated such profound ameliorations in the design of dynamos that he increased their efficiency in the most astonishing manner. Heretofore, the dynamos which had been constructed showed an efficiency not reaching over fifteen to forty per cent., gross electrical efficiency, but the new dynamos constructed after Weston's principles increased this to the unexpected efficiency of ninety-five per cent., and a commercial efficiency of eighty-five to ninety per cent. He thus marked an epoch in physical science by constructing the first industrial machine which was able to change one form of energy, motion, into another, electricity, with a hitherto unparalleled small loss. As the improvements in dynamos depend almost exclusively on physical considerations, and have little relation with the field of chemistry, I shall dispense with going further into this matter. But I should be permitted to point out that the first practical application of electrical power transmission for factory purposes in this country, was first utilized in Weston's factory; the success of this installation induced the Clark Thread Works, also located in Newark, to adopt this method of power transmission for some special work; a method which now has become so universal. For this purpose, Weston had to invent new devices for starting, and for controlling, as well as for preventing injuries to motors by overload.

In Weston's factory also the electric arc was used for the first time in the United States for general illumination.

In fact, from 1875 to 1886, Weston was very energetically engaged with the development of both systems of arc- and incandescent-illumination by electricity. We see him start the manufacture of arc-light-carbons according to methods invented by him, and thus he became the founder of another new industry in America. He continued this branch of manufacture until 1884, at which epoch this part of the business was transferred to another company, which has made a specialty of this class of products, and has developed it into a very important industry. Here again, Weston introduced chemical methods and chemical points of view. Amongst the many objections which the public had against the electrical arc was the bluish color of its light. Women especially complained that the blue-violet light did not bring out their complexion to the best advantage. Weston first tried to use shorter arcs which gave a whiter light, but this was only a partial remedy. He soon found a more radical

and more complete cure by the introduction of vapors of metals or metallic salts or oxide in the arc itself, so as to modify at will the color of the light, and thus he became the inventor of the so-called "flaming arc." It is noteworthy that it took about twenty years before electricians and illuminating engineers became so convinced of the advantages of the flaming arc, that it had to be "reinvented" during these late years, and now it is considered the most efficient system of arc-illumination.

In relation to this invention, it is interesting to quote the following extract of the specifications from his United States Patent 210,380, filed November 4, 1878:

> This rod or stick may be made of various materials, as, for example, of so-called "lime glass," or of compounds of infusible earths and metallic salts, silicates, double silicates, mixtures of the silicates with other salts of metals, fluorides, double fluorides, mixtures of the double fluorides, fusible oxides, or combinations of the fusible oxides with the silicates—the requirements, so far as the material is concerned, being that it shall be capable of volatilization when placed on the outer side of the electrode to which it is attached, and that its vapor shall be of greater conductivity than the vapor or particles of carbon disengaged from the carbon electrodes. The foreign material added to the carbon may be incorporated into the electrode by being mixed with the carbon of which the electrode is composed, or it may be introduced into a tubular carbon; but I have found it best to place it in a groove formed longitudinally in the side of the electrode, as shown.

In his endeavors to make the electric incandescent lamp an economic possibility, we see him introduce over and over again, chemical methods and chemical considerations. He first tried to utilize platinum and iridium, and their alloys, which he fused in a specially constructed electric furnace, devised by him, antedating the furnace described by Siemens. This is probably the first electrical furnace, if you will except the furnace which Hare used in his laboratory in Philadelphia.

But these platinum metals showed serious defects aside from their high cost, and by that time, Weston had become so familiar with the properties of good carbon that like other inventors, he became convinced that the ultimate success lay in that direction.

And now we see him join in that race of rivalry among inventors who all engaged their efforts in search of the real practical incandescent lamp. Among this group of men, the names of Edison here in the United States and that of Swan in England, have been best known. To go in the details of this struggle for improvement is entirely outside of the scope of this short review.

Edison succeeded in making incandescent lamp filaments by carbonizing selected strips of bamboo. But even a carbon made of this unusually compact and uniform material was far from being sufficiently regular and homogeneous. Indeed, all the then known forms of carbon conductors had the fatal defect of a structural lack of homogeneity. On account of this, the resistance varied at certain sections of the filament, and at these very spots, the temperature rose to such an extent that it caused rapid destruction of the filament; this is somewhat similar to the chain which is just as strong as its weakest link.

These irregularities in the filament reduced enormously the term of service of any incandescent lamp. Weston tried to solve this difficulty by means of his chemical knowledge. He remembered that as a boy, when he went to visit the gas works to obtain some hard carbon for his Bunsen cell, this carbon was collected from those parts of the gas retort which had been the hottest, and where the hydrocarbon gas had undergone dissociation, leaving a dense deposit of coherent carbon.

In this chemical phenomena of dissociation at high temperature, he perceived a

chemical means for "self-curing" any weak spots in the filament of his lamp. The remedy was as ingenious as simple. In preparing his filament, he passed the current through it while the filament was placed in an atmosphere of hydrocarbon gas, so that in every spot where the temperature rose highest on account of greater resistance, brought about by the irregular structure of the material, the hydrocarbon gas was dissociated and carbon was deposited automatically until the defect was cured, with the result that the filament acquired the same electric resistance over its whole length. But this invention, however brilliant, did not limit his efforts. He had become imbued with the idea that the ideal filament would be an absolutely structureless, homogeneous filament, with exactly the same composition and the same section throughout its whole length. He reasoned that such a filament could not be obtained from any natural products, neither from paper nor bamboo, but that it had to be produced artificially in the laboratory from an absolutely uniform, structureless chemical substance. After various unsuccessful attempts, he finally secured this result by applying his old knowledge of the days when he used to make collodion. He produced a homogeneous, structureless transparent film of nitrocellulose by evaporating a solution of this material in suitable solvents. As he could not carbonize this film on account of the well-known explosive properties of so-called "gun-cotton," he obviated this difficulty by eliminating the nitrate group of the molecule of cellulose-nitrate by means of ammonium-sulphydrate. This gave him a flexible, transparent sheet, very similar in appearance to gelatine; this material he called "Tamidine." Such films could be cut automatically with utmost exactitude, producing filaments of uniform section, which then could be submitted to carbonization, before fastening them to the inside of the glass bulb of the incandescent lamp.

It is interesting to note here that the modern Tungsten lamp, in all its perfection, made of ductile tungsten, is after all, the fullest development of the principle of an entirely structureless homogeneous chemical filament. The Tungsten-filament can stand much higher temperatures than carbon and this property gives it higher lighting efficiency, but the former tungsten filaments of a few years ago, which had a granular structure, had the same defect as the earlier carbon lamps, namely, a non-homogeneous texture and correspondent short life.

While Weston was wrestling with all his electrical problems, and more particularly with the construction of dynamos and motors, he was handicapped continuously by the clumsy and time-consuming methods of electrical measurements which were the best existing at that period. Up till then, these methods had been found good enough for physical laboratories, where the lack of accuracy did not result disastrously in hitting the pocket of the manufacturer, or where time—abundant time for observations and calculations—was always available. But progress in the electrical industries lagged behind the delay and uncertainties caused by electrical measurements. So Weston was compelled to invent for his own use a set of practical electrical measuring instruments. It was not long before some of his friends wanted very badly duplicates of his instruments; before he knew it, he was giving considerable attention to the construction and further development of these instruments. Just about this time, the electric light and dynamo construction enterprise entered into a new period, where they began to develop in large unwieldy commercial organiza-

tions, requiring public franchises and which had to be backed by vast amounts of new capital. In its boards of directors, business men, or financial men and corporation lawyers, became paramount factors and eclipsed in importance the technical or scientific men, who, in earlier days, had almost exclusively contributed to the development of the art.

Following his natural inclinations, Weston soon abandoned his former business connections in order to entrench himself in a field where individuality, science and technology were of almost unique importance, and which he could develop without the necessity of incurring financial obligations beyond what he could master personally. Thus he dropped his connections with the electric light and dynamo enterprises, and we see him now, heart and soul, in another new industry which he created—the art of making accurate, trustworthy and easy-to-use electrical measuring instruments. Did he foresee at that time that this art would attain the magnitude to which he has brought it to-day? Did he dream that his early modest shop was to develop into one of the most remarkably equipped factories in the world; an institution which seems the embodiment of what industrial enterprises may look like in future days, when scientific and liberal-minded management will have become the rule instead of the exception?

In his factory in Newark, Weston seems to have instilled some of his own reliability and accuracy in the minds of the men and women he employs.

In fact, has it occurred to you that even a man with the widest knowledge and the highest intelligence, who is not scrupulously reliable and careful, who is not the soul of honesty personified, could not make honest and trustworthy measuring instruments nor create reliable measuring methods?

What Stas did in chemistry for atomic weights, Weston did for electrical measuring; he created radically new methods of measurement, and introduced an accuracy undreamt of heretofore. Do not forget that his problems were not easy ones. When the British government offered a prize of $100,000 for the nearest perfect chronometer, the problem of a reliable chronometer involved considerably less difficulties and fewer disturbing factors than any of those encountered in devising and making electrical measuring instruments. But here again, even at the risk of monotonous repeating, I want to impress you with the fact that the success of the methods of Weston was found in almost every case in the application of chemical means by which he tried to solve his difficulties.

When he took up this subject, the scientists, as far back as 1884, accepted implicitly the belief that the definition of a metal and a non-metal resides in a physical distinction; that for metals the electrical resistance increased with temperature, while for non-metals, their resistance decreased with temperature. This was another one of those readily accepted axioms which nobody dared to refute or contest because they were repeated in respectable text-books. And yet, this unfortunate behavior of metals was the greatest drawback in the construction of accurate measuring instruments. Indeed, on account of the so-called temperature coefficients, all measurements had to be corrected by calculation to the temperature at which the observation was made. This seems easy enough, but it was time-consuming and often it is more difficult to make rapid accurate observation of the temperature of the instrument itself. First of all, the thermometers are not accurate, and have to be corrected periodically, and furthermore, it is not an easy matter to determine rapidly the temperature of a coil or an instrument. Moreover, by the

very passage of the electric current, fluctuating changes in temperature are liable to occur, which would make the observations totally incorrect. All this led to hesitation and slowness in measurements. Weston wanted to correct this defect, but he was told that the very laws of physics were against his attempts. Before he was through with his work, he had to correct some of our conceptions of the laws of physics; now let us see how he did it:

Weston knew that the favorite metal for resistances was so-called German-silver. Strange to say, he was the first one to point out to the Germans themselves that "German-silver" is a word which covers a multitude of sins, and that the composition of German-silver varies considerably according to its source of supply. The result was that he soon proposed a standard-copper-and-nickel-and-zinc-alloy containing about 30 per cent. of nickel, and which had a resistance of almost twice that of ordinary German-silver and a much lower temperature coefficient. Not satisfied with this, he took up the systematic study of a large number of alloys. The first batch which he undertook to study amounted to more than three hundred different alloys. Since that time, he has considerably increased this number, and is still busy at it. Every one of these alloys he made himself in his laboratory, starting from pure materials, and controlling the whole operation from the making of the alloy to the drawing of wires of determined size. By long and repeated observations, on which many years have been consumed, he was able to determine the electrical behavior of each one of these alloys at different temperatures. After awhile, he began to observe remarkable properties in some manganese alloys he compounded. He managed to produce an alloy which had sixty-five times the resistance of copper. But getting bolder and bolder, he strove to obtain an alloy which had no temperature-coefficient whatever. He not only succeeded in doing this, but finally produced several alloys which had a *negative* temperature-coefficient. In other terms, their resistance, instead of increasing with rise of temperature, decreased with increasing temperature. He also showed that the resistance of these alloys depended not only on their composition, but on certain treatments which they undergo, for instance, preliminary heating. And since that day, the physicists have had to bury their favorite definition of metals and non-metals. The present generation can hardly realize what this discovery meant at that time. I could not better illustrate this than by reminding you of the fact that in 1892, at the meeting of the British Association for the Advancement of Science, where it was urged to found an institution similar to the Deutsche Reichsanstalt, Lord Kelvin said in his speech:

The grand success of the Physikalishe-Reichsanstalt may be judged to some extent here by the record put before us by Professor von Helmholtz. Such a proved success may be followed by a country like England with very great profit indeed. One thing Professor von Helmholtz did not mention was the discovery by the Anstalt of a metal whose temperature coefficient with respect to electrical resistance is practically nil; that is to say, a metal whose electrical resistance does not change with temperature. This is just the thing we have been waiting for for twenty or thirty years. It is of the greatest importance in scientific experiments, and also in connection with the measuring instruments of practical electric lighting, to have a metal whose electrical resistance does not vary with temperature; and after what has been done, what is now wanted is to find a metal of good quality and substance whose resistance shall diminish as temperature is increased. We want something to produce the opposite effect to that with which we are familiar. The resistance of carbon diminishes as temperature increases; but its behavior is not very constant. Until within the last year or so nothing different was known of metals from the fact that elevation of temperature had the ef-

fect of increasing resistance. The Physikalische-Anstalt had not been in existence two years before this valuable metal was discovered.

Then followed this colloquy:

PROFESSOR VON HELMHOLTZ. The discovery of a metal whose resistance diminished with temperature was made by an American engineer.

PROFESSOR AYRTON. By an Englishman—Weston.

LORD KELVIN: That serves but to intensify the position I wished to take, whether the discovery was made by an Anglo-American, an American-Englishman, or an Englishman in America. It is not gratifying to national pride to know that these discoveries were not made in this country.

The misinformation of Kelvin was due to the fact that after the Weston patents had been published, his alloy was called *manganin* in Germany, and a good deal of publicity had been given to its properties with scant reference to its real inventor, an occurrence which, unfortunately, is not infrequent not only among commercial interests but in technical or scientific circles as well.

No less important was the invention of the Weston cell, which in 1908, by the international commission for the establishment of standards of electrical measurements, has become the accepted universal practical standard for electromotive force. Here again, this physical standard was obtained by chemical means.

Until Weston researches on standard cells, the Clark cell had been the standby of the electricians and electrochemists of the world, as the standard of electromotive force. It required the keen analysis of a Weston to ascertain all the defects of this cell and to indicate the cause of them. Later, he drew from his careful chemical observations, the means to construct a cell which was free from the defects of its predecessors—a cell that had no temperature-coefficient and had no "lag."

He detected that the choice of a saturated solution of sulphate of zinc in which was suspended an excess of crystals of this salt, was an unsuitable electrolyte and one of the principal causes why the indications of the Clark cell varied considerably with the temperature. It is true that this could be obviated by placing the cell in a bath of constant temperature. But this involves new difficulties due to the proper determination of the real temperature. Furthermore, there is always a "lag" in the indications due to the fact that at varying temperatures it requires a certain time before the solution of the salt has adjusted itself to the coefficient of saturation for each newly acquired temperature. By studying the comparative behavior of various salts at different temperatures, he came to the conclusion that cadmium-sulphate is more appropriate and this was one of the several important improvements he introduced in the construction of a new standard of electromotive force.

Dr. Weston assures me that he has succeeded in making his alloys to show only a change of one millionth for a variation of one degree centigrade. The metallic alloys he discovered are used practically in nearly all kinds of electrical measuring instruments throughout the world. Weston instruments and Weston methods are now found in all properly equipped laboratories and electrochemical establishments of the world. On a recent trip to Japan, I saw them in the University of Tokio, as well as in the Japanese war museum, where their battered remains attested that the Russians used them on their captured battleships. I have worked in several laboratories in Europe equipped with instruments said to be "just as good" as those of Weston, but in most instances, they were imitations of Weston instruments and it was significant that they kept at least one Weston instrument to be used to correct and compare their national product.

Like many inventors, Weston has been engaged extensively in patent litigation. To uphold some of his rights, he had to spend on one set of patents nearly $400,000, a large amount of money for anybody, but as he told me, he begrudges less the money it cost him than all his valuable time it required—a greater loss to an inventor thus distracted from his work. What is worse, most of this litigation was so long-winded that when finally he established his rights, has patents had aged so much that they had lost, in the meantime, most, if not all, of their seventeen years' terms of limited existence. And here I want to point out something very significant. In the early periods of his work, between 1873 and 1886, Weston took out over three hundred patents. Since then, he has taken considerably less, and of late, he has taken out very few patents—after he became wiser to the tricks of patent infringers. Formerly, as soon as he published his discoveries or his inventions, in his patent specifications, he was so much troubled with patent pirates that instead of being able to attend to the development of his inventions, he was occupied in patent litigation. As an act of self-preservation, he has had to adopt new tactics. He now keeps his work secret as long as possible, and in the meantime, spends his money for tools and equipment for manufacturing his inventions. In some instances, this preparation takes several years. Then by the time he sends any new type of instruments into the world, and others start copying, he has already in preparation so many further improvements that pretty soon the next instrument comes out which supersedes the prior edition. He had to utilize these tactics since he found how impractical it was to rely on his patent rights for protection. That inventors should have to proceed in this way is certainly not a recommendation for our patent system; it kills the very purpose for which our fundamental patent law was created, namely, *the prompt publication of new and useful inventions.*

L. H. Baekeland

NOTE ON THE ORBITS OF FREELY FALLING BODIES

In No. 975, Vol. XXXVIII., N.S. (September 5, 1913), of this journal, I gave a semi-popular account of an investigation on "The orbits of freely falling bodies" published in Nos. 651, 652 of the *Astronomical Journal,* August 4, 1913. Soon after the appearance of these papers several correspondents challenged the result I derived for the meridional deviation of the falling body, all of them maintaining that this deviation is toward the equator instead of away from it, as I had concluded. Being preoccupied with affairs somewhat remote from the fields of mathematical physics, I have not been able to give this apparent discrepancy adequate attention, although its origin was indicated in an informal communication to the Philosophical Society of Washington in April, 1914.

In the meantime, two noteworthy contributions to the already extensive literature of this subject have been published by Professor F. R. Moulton[1] and by Professor Wm. H. Roever,[2] respectively. These contributions are not only important for originality of methods and for painstaking attention, especially to mathematical details, but they may seem to the casual reader to have exhausted the subject by demonstrating in the most approved mathematical fashion of our day that the postulates

[1] "The Deviations of Falling Bodies," *Annals of Mathematics,* Second Series, Vol. 15, No. 4, pp. 184–94, June, 1914. This investigation is specially remarkable in that but one kind of latitude is used. It is likewise remarkable in that no explicit statement is made as to which of the various latitudes (astronomic, geocentric, geodetic or reduced) is used.

[2] "Deviations of Falling Bodies," *Astronomical Journal,* Nos. 670–672, pp. 177–201, January 22, 1915.

adopted and the results derived are at once unique, "necessary" and "sufficient." Both authors insist with much particularity that the discrepancy between us is due to superior methods of approximation followed by them in integrating the fundamental equations of motion, since we all agree on the forms of these equations.

But the subject is not thus easily disposed of. A sense of humor should lead us to inquire whether the parties concerned have all solved the same problem. The answer to such an inquiry in this case is that while all have ostensibly treated the same problem, two different problems have actually been solved. We have thus developed a fresh illustration of a common danger in mathematical physics, namely, that of fixing attention on mathematical perfection before adequate regard has been given to physical requirements.

It would be out of place in the columns of this journal to enter into a review of the details of the investigations of Professor Moulton and Professor Roever. Such a review is, in fact, neither desirable here nor essential in a technical publication. The source of the discrepancy referred to is so evident that it needs only to be stated to be appreciated; and once stated there is no ground for controversy in this part of the subject. It appears desirable, however, to refer in some detail to the general considerations involved in deriving the orbits of falling bodies as well as to those special considerations which determine meridional deviations. For this purpose it will be essential in a limited degree to use the abridged language of analysis.

But before adducing these considerations I wish to plead guilty to an oversight in reading Professor Roever's earlier papers[3] and to submit a brief of extenuating circumstances. At first reading of these papers it appeared to me that he had neglected terms involving the square of the angular velocity of the earth in his equations of motion of the falling body. These terms do not appear explicitly in those equations, but only implicitly through a special potential function used by him for the first time, apparently, in this connection. Not being able to follow his derivation of these equations (if, indeed, he may be said to have derived them in the mechanical sense), I assumed them to be identical in meaning, as they are in form, with those published by several earlier writers. This assumption was supported by uncertainty as to meaning and by lack of homogeneity of his expression for the potential function introduced on page 342 of his first paper; and still more by his identification of astronomic with geocentric latitude (on p. 339, same paper) by means of the loose phrase "with sufficient approximation." A similar lack of "accuracy and precision" will be found in several parts of his latest paper cited above. See, for example, his equations (j), wherein he confounds geocentric with reduced latitude; also p. 199, where he identifies his equations (38) and (41) with my equation (26) and makes with respect to them the surprising statement that "it is, of course, evident that this function corresponds to some distribution of revolution" in the earth's mass. Concerning the absence of validity for this latter statement some remarks are made below.

Now, to account for the discrepancy in question, namely, our differing values for the meridional deviation of the falling body, it is only essential to observe that two different surfaces of reference have been used. Professors Moulton and Roever have referred the motion to a geoid specified by a certain approximate potential function, while I have referred the same motion to Clarke's spheroid of revolution (of 1866), which is determined by certain axes (a, b) dependent on geodetic measurements. These surfaces are not coincident to the order of approximation adopted by either party, and the discrepancy developed appears to be both "necessary" and "sufficient" to restore confidence in the mathematical mills of all concerned.[4]

[3] "The Southerly Deviation of Falling Bodies," *Transactions of the American Mathematical Society*, Vol. XII., pp. 335–53. "The Southerly and Easterly Deviations of Falling Bodies for an Unsymmetrical Gravitational Field of Force," *Ibid.*, Vol. XIII., pp. 469–490.

[4] It has been known since the earlier writings of Airy that the geoid and the spheroid are not coincident, but I was not aware that their inclination

To put this statement in a clearer form for the mathematical reader, let V denote the gravitational potential per unit mass at a point outside, or on, the earth, and let r and ψ denote, respectively, the radius vector and the geocentric latitude of that point. Then, if ω denote the angular velocity of the earth and if the point (r, ψ) is attached to and rotates with the earth, the expression

$$V + \tfrac{1}{2}\,\omega^2 r^2 \cos^2 \psi$$

is the potential per unit mass at that point due to the attraction and to the rotation of the earth. Calling this expression U,

$$U = V + \tfrac{1}{2}\,\omega^2 r^2 \cos^2 \psi = cons't \qquad (1)$$

specifies a family of equipotential surfaces about the earth. Thus, for example, $U = constant$ specifies the sea surface, provided V, r, ψ have appropriate values, and this surface, which may be imagined to extend through the continents, is called the geoid. Similarly, corresponding surfaces above and below the sea surface are geoidal and may be used, like the sea level, as surfaces of reference.

Adopting for the moment the simpler hypothesis that the shape of the geoid does not depend on longitude, the divergence from parallelism of the geoid (1) and the spheroid (a, b) may be defined in the following manner. Since the linear acceleration components along and perpendicular to the radius vector r at the point (r, ψ) of the geoid $U = constant$ are, respectively,

$$\frac{\partial U}{\partial r} \quad \text{and} \quad \frac{\partial U}{r \partial \psi},$$

the tangent of the angle between r and the normal to the geoid at the same point is given by the quotient of the second by the first of these partial derivatives.[5]

The angle thus derived is the difference between the astronomical latitude, ϕ_0, say, and the geocentric latitude ψ of the point (r, ψ). Using the data for V and r adopted in my paper cited above, it is found that the general value of this difference is to the first order of approximation, and in seconds of arc,

$$\phi_0 - \psi = 688'' \sin 2\phi_0. \qquad (2)$$

On the other hand, the difference between the geodetic latitudes ϕ, say (determined by the normal to the spheroid (a, b)), and the geocentric latitude of the same point, is to the same order of approximation

$$\phi - \psi = 700'' \sin 2\phi. \qquad (3)$$

There is thus a systematic difference between these two quantities, since the residuals $(\phi_0 - \phi)$, or the so-called plumb-line deflection in the meridian, are assumed to be of compensating plus and minus magnitudes in determining the spheroid (a, b). Otherwise expressed, this systematic difference is such as to make the value of the meridional deviation of the falling body vanish to terms of the order of ω^2 inclusive, adopted in my investigation, if reference is made to the geoid instead of to the spheroid; and to this order of approximation the discrepancy is completely accounted for.

It is evident that we may not discard either in favor of the other, of the two surfaces of reference giving rise to this discrepancy, since their departure from coincidence is an index of our ignorance of the geoid especially and to a less extent also of the spheroid used. The geoid specified by equation (1) is obviously less well known than the spheroid, since an assumption must be made concerning the distribution of density in the earth before the moments of inertia which determine the geoid can be computed. Thus the relation (2) is known with less precision than the relation (3); but it is now clear that a complete treatment of the problem in question requires that both of these relations be taken into account along with the additional relations $(\phi_0 - \phi)$ and $(\lambda_0 - \lambda)$, say, or the plumb-line deflections in latitude and longitude, respectively, at the point (r, ψ, λ). That considerable uncertainty attaches still to the relation (3) is indicated by the range in the following values for the coefficient of sin 2ϕ derived by some earlier and by some more recent writers in geodesy.

could figure sensibly in the orbits of falling bodies when my first investigation of these orbits was published.

[5] To terms of the order of ω^2 inclusive this tangent, using the notation of my paper cited above, is

$$\frac{\tfrac{1}{2} r \left(\omega^2 + \dfrac{3\beta}{r^5}\right) \sin 2\psi}{\dfrac{\alpha}{r^2} + \dfrac{3\beta}{2r^4}(1 - 3\sin^2\varphi) - \omega^2 r \cos^2\psi}.$$

Bessel, 1841	690.6″
Clarke, 1866	700.4″
Harkness, 1891	688.2″
Hayford, 1909	695.8″

It appears essential in this connection to call attention to a common misapprehension with respect to the earth which Professors Moulton and Roever have helped to disseminate by their able contributions to the subject before us. The potential function V which appears in equation (1) above, may be developed in a series of spherical harmonics whose first three terms are given in the second member of the following equation:

$$V = \frac{Mk}{r} + \frac{k}{2r^3}\{C - \tfrac{1}{2}(B + A)\}(1 - 3\sin^2\psi) + \frac{3k}{4r^3}(B - A)\cos^2\psi\cos 2\lambda. \tag{4}$$

In this r, ψ, λ are, respectively, the radius vector, geocentric latitude and longitude of the point, outside the earth, to which V applies. M is the mass of the earth, k is the gravitation constant and A, B, C are in order of increasing magnitude the moments of inertia of the earth with respect to a set of principal axes originating at its centroid. C is commonly said to be the moment with respect to the axis of rotation of the earth, but in these days of "variation of latitudes" and of "mathematical rigor," it should be said to apply to the axis of figure nearest the axis of rotation. A and B are then the moments with respect to the principal axes in a plane through the centroid and normal to the axis of C, or in the plane of the equator as we commonly say.

The expression (4) has very remarkable properties. It is equation (26) of my paper cited above. The value of V is the same whether the latitude ψ is positive or negative; and dependence on longitude vanishes if $B = A$. With respect to this equation Professor Moulton remarks "If the rotating body is a figure of revolution about the axis of rotation whose density does not depend upon the longitude, the function V can be developed as a series of zonal harmonics in the form

$$V = \frac{\alpha}{r} + \frac{\beta}{r^3}(1 - 3\sin^2\varphi)."$$

A similar remark with regard to this expression has been quoted above from Professor Roever, the inference being, apparently, that in some manner the expression (4) limits the distribution of the earth's mass to one of revolution. As a matter of fact, however, the expression (4) implies no such restriction; on the contrary, it applies equally to a body of any form and of any distribution of density, the sole requirement being that the point (r, ψ, λ) lie at a distance from the centroid of the body equal to or greater than the greatest distance of any element of mass in the body from the same point. The considerations which permit us to assume $(B - A)$ small, or possibly negligible, in this and other problems of geodesy, must depend, unfortunately, on other sources of information than the expression (4). Some attention to these considerations was given in each of my papers referred to in the first paragraph of this note.

Without going further into the subject at this time it may suffice to remark that it now appears illusory except as a mathematical exercise to push the solution of the differential equations of motion of a falling body to terms involving the second derivatives of V without including the third term in the right-hand member of (4), without taking account of the known relation between these derivatives, and without taking account of plumb-line deflections, which often exceed the discrepancy shown by equations (2) and (3).

R. S. WOODWARD

February 22, 1915

ARTHUR VON AUWERS

THE problems that confront the astronomer differ from those with which workers in other departments of science are engaged in many important particulars, but in none more than in the magnitude of the data involved. So great is the number of the stars, so vast, both in space and in time, the scale of their motions, that in general it transcends the powers of an individual, or even of a single observatory, to collect, within the span of a lifetime, the materials for comprehensive studies, or to collate and discuss them. Cooperation is probably

more essential to progress in astronomy than in any other science.

The earliest example of cooperation on a large scale in astronomical research was the proposition brought forward by Argelander and his associates, half a century ago, for the formation of a great catalogue of all the stars to the 9th magnitude in the northern sky. At the meeting of the Astronomische Gesellschaft in 1869, when, after four years of preliminary discussion, the project was formally initiated, the plan of work adopted was the one presented by Dr. Arthur Auwers, a young astronomer, who, three years earlier, had been elected to membership in the Berlin Academy of Sciences to fill the place left vacant by the death of Encke. In view of Auwer's youth—he was then only 31—this was a notable recognition of his ability. But even more significant was the fact that to him was also entrusted the all-important duty of preparing the system of fundamental star places which provided the foundation for the entire work.

It is impossible, without running unduly into technicalities, to give an adequate idea of the difficulties attending the construction of such a fundamental system of star places. It must suffice to say that it requires the highest order of ability, a profound grasp of the principles of gravitational astronomy, a comprehensive knowledge of star catalogues, rare judgment, and a mastery of detail that is given to but few minds. How well qualified Auwers was for the responsibility placed upon him is evident from the fact that the fundamental system he elaborated more than 40 years ago is adopted, in all its essentials, as the foundation of the greater part of the most refined meridian circle work of the present day.

His connection with the "Astronomische Gesellschaft Catalogue" did not end with the service I have described. In addition, he undertook the observation of one of the sections or "Zones" of the catalogue—producing a model work—and was soon made chairman of the commission in charge of the entire project —a position he held to the date of his death, January 24, 1915. Its success, therefore, is in large measure due to his careful planning and wise guidance. Long before his death he had the satisfaction of seeing the original catalague completed by contributions from no less than twelve great observatories in Europe and America, and of having the plan extended, again under his direction, well into the Southern Hemisphere.

G. F. J. Arthur Auwers was born in Göttingen in 1838 and received his early education in the schools of his native city. His interest in astronomy was manifested when he was still a mere boy, and even before he received his doctor's degree at Königsberg in 1862, he had made many important contributions to it both by observations and by theoretical investigations. His dissertation for the doctorate, on the variable proper motion of Procyon, placed him at once in the front rank of astronomers. In this research he struck the keynote of his future life-work, "the treatment of all questions concerning the positions and motions of the stars."

I shall not attempt even to enumerate his many contributions to this department of astronomy. His services to the A. G. Catalogue have already been mentioned. It must suffice to describe briefly one other research, in many respects his most important—the new reduction of the Bradley stars.

The fundamental data upon which all studies of the mechanics of the stellar universe depend are the positions of the stars on the celestial sphere, their apparent motions on this sphere (technically, their "proper motions"), their radial velocities and their distances. The first two of these elements are derived from the star catalogues based on meridian observations. One of the most important of all star catalogues is that based upon the observations of Bradley, at Greenwich, about the middle of the eighteenth century, for these observations were the first that are at all comparable in system and in accuracy with those of modern times, and they were also superior to those of his successors for fully half a century. As the time element is of the first consequence in the derivation of stellar proper motions, Bessel, who in 1819 made the first reduction of the Bradley observations, was fully justified in giving his work the title "Fundamenta Astronomiæ." Excellent as Bessel's work was,

the rapid progress of astronomy in the next half-century led to a more accurate knowledge of the fundamental astronomical constants and to more refined methods in the reduction of meridian observations, and it also became evident that some of his assumptions respecting Bradley's instrument were erroneous. A new reduction was therefore highly desirable and this was undertaken by Dr. Auwers in 1866. He brought all his skill and special knowledge into play and spared no pains to insure the utmost accuracy in his work. The result of the ten years' labor it involved has been well called a "masterpiece and a model." The Auwers-Bradley catalogue at once became the starting point for all discussions of proper motions—a position it will probably hold for all time.

His fundamental system of star places, the Auwers-Bradley catalogue, and his other work in related fields, will form Auwer's most enduring monuments, but they are far from comprising the full measure of his activities. Thus, he was chairman of the German Commission for the determination of the solar parallax from the transits of Venus in 1874 and in 1882. He took the leading part in preparing the observing programs, conducted in each year one of the expeditions sent out by the government, and personally directed the elaborate discussion of all the results—a truly monumental work which fills six large quarto volumes.

From 1878 to 1912 Auwers held the position of Secretary of the Section for Mathematics and Physics in the Royal Prussian Academy of Sciences (Berlin Academy) and his tactful conduct of the manifold duties of this office, together with his unselfish and tireless devotion to the interests of the academy were gratefully acknowledged by his colleagues at the meeting of June 25, 1912, when they celebrated his jubilee—the fiftieth anniversary of his graduation as doctor of philosophy.

He founded the bureau of the "History of the Sidereal Heavens" (Geschichte des Fixsternhimmels) whose object it is to collect all of the meridian observations of stars since Bradley's time and to combine them into a single systematic catalogue. He was a member of the commission charged with the organization of the Astrophysical Observatory at Potsdam, and assisted in the supervision of its construction and of its management in its early years. He was also the first president of the International Association of Academies.

Auwers's commanding position in his chosen science was fully recognized in his own country and throughout the world. His own government gave him the title Wirklicher Geheimer Ober-Regierungsrat, and at the time of his death he was Kanzler des Ordens pour le mérite für Wissenschaft und Künste. For more than twenty years before his death he had been a member of the seven leading National Academies of Science in Europe and America, a distinction in which but two other astronomers of his generation shared—Newcomb and Schiaparelli. In 1888, he was awarded the gold medal of the Royal Astronomical Society of London, in 1891, the Watson gold medal of our National Academy, and in 1899, the Bruce gold medal of the Astronomical Society of the Pacific. His death marks the passing of one of whom Newcomb wrote, nearly twenty years ago, "To-day, Auwers stands at the head of German astronomy. In him is seen the highest type of the scientific investigator of our time." These sentences well express the judgment of all astronomers at the present day.

R. G. AITKEN

March 22, 1915

SCIENTIFIC NOTES AND NEWS

A MEETING to commemorate the life and scientific work of the late Charles Sedgwick Minot was held on March 17, in the hall of the Boston Society of Natural History. As president of the society since 1897, Dr. Minot had taken great interest in its welfare and growth, and it was due in large part to his efforts that the society has undertaken the study and exhibition of the natural history of New England as its special field. At the meeting addresses were made by Dr. Henry H. Donaldson, of the Wistar Institute of Anatomy and Biology, and Dr. Charles W. Eliot, of Cambridge. Dr. Donaldson especially dwelt upon Minot's early interest in natural history and his scientific career. Dr.

Eliot brought out particularly his great accomplishments for Harvard University in the development of teaching and research in the medical school, and emphasized the remarkable personal qualities that fitted him for this work.

THERE was printed in SCIENCE last week a list of the fifteen candidates selected by the council for election into the Royal Society. The *British Medical Journal* gives information in regard to their positions and work which we reproduce. The men are: Dr. F. W. Andrewes, professor of pathology in the University of London and pathologist to St. Bartholomew's Hospital; Dr. A. W. Conway, professor of mathematical physics, University College, Dublin; Mr. L. Doncaster, superintendent of the University Museum of Zoology, Cambridge, well known for his researches into the Mendelian hypothesis; Mr. J. Evershed, director of the Solar Physics Observatory, Kodaikanal, India; Dr. Walter Morley Fletcher, secretary of the Medical Research Committee established under the Insurance Act; Mr. A. G. Green, professor of tinctorial chemistry, University of Leeds; Mr. H. H. Hayden, director of the Geological Survey of India; Dr. James Mackenzie, whose researches into the action of the heart in health and disease have made his name well known to the profession; Dr. J. C. McLennan, professor of physics, University of Toronto; Dr. A. T. Masterman, fisheries inspector; Dr. G. T. Morgan, professor of chemistry in the Royal College of Science, Dublin; Dr. C. S. Myers, director of the laboratory of experimental psychology, Cambridge; Mr. G. C. Simpson, imperial meteorologist, India; Mr. A. A. Campbell Swinton, one of the early workers with the X-rays and wireless telegraphy, and Mr. A. G. Tansley, lecturer on botany, University of Cambridge.

THE dedicatory exercises of the new buildings of the Washington University Medical School will be held April 29 and 30. According to the *Journal* of the American Medical Association the exercises include, in addition to the various entertainments, addresses by the dean of the medical school, Dr. Eugene Lindsay Opie; by Dr. William Henry Welch, Baltimore, of Johns Hopkins University; President Abbott Lawrence Lowell, of Harvard University; President Henry Smith Pritchett, of the Carnegie Foundation for the Advancement of Teaching; President George Edgar Vincent, of the University of Minnesota; Drs. William Townsend Porter, Robert James Perry, Fred Towsley Murphy and George Dock, of Washington University, Abraham Flexner, assistant secretary of the general education board, and Major-General William Crawford Gorgas, surgeon-general U. S. Army. On April 28, exercises in commemoration of Dr. William Beaumont will be held, including the presentation of the manuscripts and letters of William Beaumont to Washington University Medical School, the acceptance of the gift by the chancellor of the university, and addresses on "William Beaumont as a Practitioner," by Dr. Frank J. Lutz, and "William Beaumont as an Investigator," by Dr. Joseph Erlanger.

ACCORDING to *Nature* the Imperial Society of Naturalists of Moscow has removed the names of Professor Haeckel and Professor Ostwald from the list of members on account of their having signed the address, "To Civilized Nations."

PROFESSOR VICTOR HENSEN, the well-known physiologist of Kiel, has celebrated his eightieth birthday.

DR. JOHN R. MURLIN has been granted leave of absence from Cornell University Medical College, New York City, to accept a temporary appointment as biochemist at the Pellagra Hospital of the Public Health Service at Spartanburg, S. C.

PROFESSOR BENJ. L. MILLER, head of the department of geology of Lehigh University, has left for an extended trip through South and Central America in company with Dr. Joseph T. Singewald, Jr., associate in economic geology in Johns Hopkins University. Most of their time will be spent in the various mining districts of the countries visited, but they will make some other geologic investigations, especially in the Andes, where

they hope to study some of the highest volcanic peaks.

DR. PHILIP J. CASTLEMAN, who has held the position of assistant director of the bacteriological laboratory of the Boston Board of Health, has been appointed director of the laboratory. He succeeds Dr. James J. Scanlan, whose death occurred recently.

COOPERATIVE agreements have been effected by the Oregon Agricultural College and the Drainage Division of the United States Department of Agriculture, whereby extensive drainage operations will be carried on in Oregon during the coming year. Mr. Guy N. Hart, of the federal department, and Professor W. L. Powers, irrigation and drainage specialist of the college, expect to begin operation about April 15.

DR. ERNEST ANDERSON, professor of general and physical chemistry at the Massachusetts Agricultural College, has had under consideration the position as head of the department of science of the Margaret Morrison School of the Carnegie Institute, Pittsburgh, Pennsylvania, but has decided to remain in Massachusetts.

FRANKLIN C. GURLEY, a graduate assistant in chemistry at the Massachusetts Agricultural College, has accepted a position as chemist with the Benzol Products Company of Philadelphia.

THE third annual Faculty Research Lecture at the University of California was given by Professor Armin O. Leuschner on March 23 on "Recent Progress in the Study of Motions of Bodies of the Solar System."

THE annual meeting of the Syracuse University Chapter of the Alpha Omega Alpha Fraternity was held March 18. A banquet was served at which the guest of honor was Dr. Walter B. Cannon, of Harvard University, who delivered an address on "The Psychology of Martial Emotions."

AT a general meeting of the New York Academy of Sciences and its affiliated societies on March 22 at the American Museum of Natural History there was a social hour, with refreshments, beginning at 9:30 P.M., preceded, at 8:15 P.M., by a lecture under the auspices of the Section of Anthropology and Psychology, entitled, "Incidence of the Effect of Moderate Doses of Alcohol on the Nervous System," by Professor Raymond Dodge, of Wesleyan University.

DR. AUGUSTUS H. GILL, professor of technical analysis at the Massachusetts Institute of Technology, addressed the Detroit Engineering Society on March 19 on "Lubricating Oils: Essentials and Characteristics."

DR. GEORGE W. CRILE repeated his lecture on "Education and War" in the Amasa Stone Memorial Chapel, Western Reserve University, on the evening of March 31. Dr. Crile consented to repeat his lecture by reason of the great numbers who were unable to gain admission at its first delivery.

MR. F. H. NEWELL, head of the United States Reclamation Service, addressed the students of the College of Engineering, University of Illinois, on March 24, on the subject of "The Engineering and Economic Results of Reclamation Work."

PROFESSOR CHAS. BASKERVILLE lectured before the Princeton Chemical Society on February 25, on "Physical Chemistry and Anesthesia."

PROFESSOR H. P. TALBOT, of the Massachusetts Institute of Technology, lectured on "The Noble Gases," on March 25, before the Phi Lambda Upsilon of Columbia University.

THE fifth annual May lecture of the Institute of Metals, London, will be given on May 12 by Sir J. J. Thomson.

A SPECIAL lecture on the septic infection of wounds was delivered before the Royal Society of Medicine, London, on March 30, by Sir Almroth Wright, who dealt with the results of his investigations and research with the expeditionary force.

A STATE biological survey, suggested by the Ohio Academy of Science, is being undertaken with a state appropriation of $2,500, a number of the colleges of the state cooperating. The preparation of duplicate material and separate collections for the colleges and other educational institutions is the primary feature of the work.

Dr. Sidney Coupland has been appointed Harveian orator of the Royal College of Physicians, London, for 1915; Dr. J. Michell Clarke Bradshaw lecturer for 1915, and Dr. Samson G. Moore Milroy lecturer for 1916.

Lady Huggins, widow of Sir William Huggins, the distinguished astronomer, and known for her scientific work, died at her home in London, on March 25. Lady Huggins was born in Dublin and married Sir William Huggins in 1875. She was joint author with him of many scientific papers, and of an Atlas of Representative Stellar Spectra. She was the author of a monograph on the Astrolabe; of articles in the Encyclopædia Britannica, and of papers in astronomical and archeological journals.

Professor Neuhauss, of Berlin, noted for his anthropologic investigations and his work in the field of color photography, has died at the age of fifty-nine years from diphtheria, contracted while engaged in military hospital work.

Dr. Clon Stéphanos, director of the Anthropological Museum of the University of Athens, died on January 24, at the age of sixty years.

A correspondent informs us that the following German zoologists have been killed in the war: Professor Stanislaus von Prowasek, head of the zoological department of the Institute for Tropic Diseases, Hamburg; Dr. W. Meyer, assistant in the same institute; Dr. W. Mulsow, assistant in the protozoological department of the Institute for Infectious Diseases, Berlin; Dr. G. Kantsch, docent for zoology, Kiel; Dr. v. Steudell, Edinger Institut, Frankfurt; Dr. v. Müller, assistant in the Zoological Institute, Kiel; Dr. v. Greinz, assistant in the Zoological Institute, Königsberg. The following have been wounded, but have in some cases recovered: Professor O. zur Strassen, professor of zoology, Frankfurt; Professor L. Rhumbler, professor of zoology, Forest School, Minden; Dr. W. Reichensperger, docent for zoology, Bonn; Dr. C. Thienemann, docent in Münster.

The American Ethnological Society has addressed the following reply to the French universities, which have addressed the scientific bodies of neutral countries, setting forth their view of the causes of the war:

The American Ethnological Society acknowledges the receipt of the communication of the French universities to the universities of the neutral countries, dated November 3, 1914, and takes the opportunity to express its sincere sympathy for the sufferings that the present war is inflicting upon France and other European countries.

The society appreciates and respects the sentiments that have dictated the statement transmitted to it, but believes, regardless of the feelings of the individual members, that it behooves it to listen with the same respect that it gladly grants to you to the statements emanating from other nations. The society, being located in a neutral country, does not share the passions engendered by the patriotic feelings of the citizens of all the contending nations. It is conscious, however, that if the United States of America should find themselves involved in a similar struggle, our members might feel the same intense desire to convince the world of the righteousness of their cause as impels at present French, German and British scholars.

At present, on account of the remoteness from warlike passions, the society is mindful that the time will come (and we devoutly hope it may come soon) when the universities and scientists of the whole world may work together again for the true ideals of mankind, that know no national boundaries, when respect for the individuality of each nation may again take the place of harsh recrimination, when the true spirit of cooperation that has characterized scientific work of the past century may reappear. When that moment arrives, the passionate expressions of an excited time will not and must not stand in the way of mutual understanding and of a renewal of old friendships.

The council of the Society of American Bacteriologists has decided to hold a special summer meeting in San Francisco, August 3, 4 and 5, 1915. The chairman of the local committee of arrangements is Dr. Wilfred H. Manwaring, Stanford University, California.

The Princeton University Observatory has received from Mr. Archibald D. Russell, of New York, a gift of the sum necessary for the carrying on for five years of its share of the work described in Professor Pickering's summary of the present needs of astronomical research (Science, January 15, 1915).

Through the efforts of Dr. Ralph Arnold, and other alumni of the department of geol-

ogy and mining, Stanford University has just added to its collections the working library and material of the late Professor Henry Hemphill, of Los Angeles. The collection contains between 8,000 and 9,000 specimens of shells and 150 volumes. The material is of very great importance in the study of the Tertiary geology of the Pacific coast, and especially of the geology of the petroleum deposits of California.

THE trustees of the Presbyterian Hospital, New York City, have taken an option to purchase the former American League baseball grounds, bounded by Broadway, Fort Washington avenue, 165th and 168th Streets. This site is owned by the New York Institute for the Education of the Blind, which has been holding it in the market at $2,000,000. Purchase of the site is made possible by the bequests of the late John S. Kennedy, by whose will the hospital receives about $2,500,000. It is understood that the College of Physicians and Surgeons, the medical school of Columbia University would be removed to the new site. Mr. Edward S. Harkness gave, in 1910, $1,500,000 toward an alliance between the hospital and the university.

UNIVERSITY AND EDUCATIONAL NEWS

BY the will of General Brayton Ives, of New York City, the largest part of his estate is bequeathed to Yale University for its general purposes. The daily papers estimate the value of the bequest at from $750,000 to $1,500,000.

MR. W. E. ALLEN, of Sheffield, has bequeathed about $750,000 to public purposes, including $25,000 and part of the residuary estate to the University of Sheffield for work in applied science.

ACCORDING to private information received from Mexico, the Carranza government has closed all educational and scientific institutions in Mexico, including not only the University, the Geological Institute, the Medical Institute and the National Museum, but also all normal schools, high schools and elementary schools under its control.

THE department of chemistry at Iowa State College, Ames, Iowa, is now installed in the new chemistry building which replaces the one destroyed by fire in March, 1913. The building is constructed entirely of brick, stone and concrete and is as near fireproof as possible. The initial cost was $200,000, and the building is 244 feet by 162 feet; three stories high, with a usable basement.

THREE Whiting fellowships in physics, each with an income of $600, for the college year 1915–16, have been filled at the University of California. Fellowships on this endowment fund are conferred for the purpose of furthering advanced study, either abroad or at an American university.

STUDENTS in the newly established forestry school at the University of California are to receive instruction in game conservation. They will be taught to recognize at sight the different species of game fish and animals and will be informed as to the economic value of each and the means by which they can be conserved. Dr. H. C. Bryant, in charge of the bureau of education, publicity and research recently established by the California Fish and Game Commission, will give the introductory lectures. He will be followed by N. B. Scofield, in charge of the department of commercial fisheries, and Dr. W. P. Taylor, curator of mammals in the University of California Museum of Vertebrate Zoology.

DR. ANDREW HUNTER, of the Cornell Medical School, has been appointed professor of pathological chemistry in the University of Toronto.

DR. R. TRAVERS SMITH has been appointed to the chair of materia medica, therapeutics and pharmacology in the school of surgery of the Royal College of Surgeons in Ireland.

DISCUSSION AND CORRESPONDENCE

EVIDENCE BEARING ON THE ORIGIN OF HUMAN TWINS FROM A SINGLE OVUM

ON the supposition that twins originate always from two ova, and that the chances are even as to whether an individual of a pair of twins is to be male or female, the ratio of like pairs to those whose members are of different sex may be worked out according to the laws of chance. The Mendelian ratio

under corresponding circumstances is 1:2:1; that is, there should be one pair of boys, to two mixed pairs, to one pair of girls. In other words, if the members of a pair of twins always developed from separate ova, we should expect to find twice as many pairs whose members differ in sex, as there are pairs of girls, or pairs of boys. I have been able to think of no factor which may reasonably be supposed to be acting in a constant direction to alter this ratio.

I have undertaken to compare with this hypothetical ratio the ratio found among births of twins in this country. My data number 3,334 twin births which occurred in the states of Connecticut, Maine and Vermont during the years 1899 to 1912. Of this number 1,118 are pairs of boys, 1,193 are boy and girl, and 1,023 are pairs of girls. This is almost a 1:1:1 ratio, showing the effect, however, of the predominance of male births. There is obviously a large excess of pairs similar in sex over what is to be expected on the supposition that twins originate in all cases from separate ova, an excess of more than 500 pairs of boys, and almost 500 pairs of girls.

This seems to point towards the conclusion that twins may originate from a single fertilized ovum. In the light of present knowledge this certainly is a possible explanation of the statistics. If the figures given will bear this interpretation, we may say that less than half (44.3 per cent.) of the twin births of similar sex, or less than one third (28.4 per cent.) of all twins, originate from one ovum, while slightly more than half (55.7 per cent.) of those of similar sex have developed simultaneously from two separate ova.

Margaret V. Cobb

Falls Church, Va.

NATURALIST'S DIRECTORY

To the Editor of Science: As you have given liberal space to criticize the book, you will doubtless be willing to give space in which I can explain the matter.

In the first place this book has not been issued for some eight years, and in getting out the new edition I decided that not a single name would be included unless I had a request that the name should be included from each party. If you find that there are a good many naturalists omitted from the directory, it was because they were too busy, or more likely too careless of such matters to take time to return the blanks which I sent them. Every naturalist of any consequence, and a great many collectors, received three notices each and none of the names were included in the book unless they replied.

Since getting out the work some of these noted scientists have taken time to write three or four criticisms of the book, while they would not take time before publication to even sign their names to the blanks I sent them. There are a few typographical errors in the book as there are bound to be in any work of this kind, and the transposition of two or three entries, to which you have taken great pains to call attention, was caused by the misplacement of one or two linotype slugs.

It is my intention to get out another edition of the Naturalist's Directory in a year from now, and I hope naturalists, generally, will be as free with their assistance in bringing the new edition up to date, as they have been in criticizing the edition just published.

S. E. Cassino

Salem, Mass.

SCIENTIFIC BOOKS

Die Variolation im achtzehnten Jahrhundert. Ein historischer Beitrag zur Immunitätsforschung. By Arnold C. Klebs. Giessen, A. Töpelmann. 1914. 8vo. Pp. 78.

Few physicians know that throughout the entire eighteenth century, and before Jenner's time, there was a vast wave of experimental research in the problem of preventive inoculation against disease, now almost forgotten. Starting in 1713, it passed into a period of twenty years' stagnation about 1727, with a revival in 1746 and a truly scientific phase during 1764–98. When a bibliography of some 600 titles, by the author of the above monograph, was shown to a highly educated physi-

cian, he said: "Yes, but all that is merely a fragment of the huge literature of vaccination!" not realizing that variolation and vaccination are distinct and separate episodes in medical history. Variolation is preventive inoculation against smallpox by means of virus taken from the human subject. In vaccination, the virus is supposed to be modified or attenuated by transmission through the body of the cow. The recent application of such terms as "vaccines" or "vaccinotherapy" to diseases other than smallpox, although now likely to remain current, is inexact and unscientific, since none of the non-Jennerian "vaccines" are passed through the cow.

Dr. Klebs, who has gone into this subject more extensively than any one else, has, in his memoir, amplified the admirable paper, read at the Johns Hopkins Hospital in 1912, by an examination of literature covering over 1,200 titles.[1] Only von Pirquet has appreciated the importance of this vast literature, which he has declared to be too overwhelming and distracting for investigation. The object of Klebs's memoir is to show the importance of "historical medicine" in the illumination or interpretation of present-day problems. For instance, the extensive experiments in inoculation of smallpox which Councilman, Brinkerhoff and Tyzzer made upon anthropoid apes at Manila, did not throw any such light upon the subject as the thousands of successful inoculations made upon man in the eighteenth century. Dr. Klebs regards variolation as a remarkable example of the value of folk intuitions in etiology and therapy. Many important advances in practical medicine have undoubtedly come from the non-medical, but these can hardly be said to have arisen from the great mass of the people, rather, on the primitive minds, *adscripti glebæ,* whose mental development was a little higher than the average. The usual process in evolution is that out of a vast number of people of primitive minds, *adscriptus glebæ,* whose mental processes are nearly all exactly alike, there arises occasionally one in whom a more specialized type of mind is born, through suffering or other experience. Then, as Emerson says, "all things are at stake." The interesting thing about variolation is that, like the primitive chipped flints all over the globe, or the ever-recurring *themata* of folk-lore, it seems to have arisen spontaneously among different savage or semi-civilized races. In this monograph it is shown that variolation has been practised from a remote period in China and India and among such African tribes as the Somalis, Ashantis and Wagandas. Cotton Mather is said to have first heard of the practise from his African slave, Onesimus. Baas's statement that inoculation is mentioned in the Atharva Veda is, however, unverifiable. In Germany and Russia, the custom of "buying the smallpox" was known from the seventeenth century on, variolation being produced by bringing the scabs, purchased in open market, or the pus in contact with the skin. This was probably a phase of the ancient superstition of the sympathetic transference of disease. In 1713, smallpox inoculation was brought to European attention from Oriental sources by Emanuel Timoni, who had his daughter inoculated in 1717. Lady Mary Montagu followed with the inoculation of her infant daughter in April, 1721, and, on June 26, 1721, Zabdiel Boylston of Boston, Mass., began his long series of inoculations in which, by 1752, he had 2,124 cases, with only 30 deaths, while, in 1743, Kirkpatrick, in South Carolina, had nearly 1,000 cases, with 8 deaths. At this time the *modus operandi* was incision, with sometimes a dietetic and depletory "preparation," usually blood-letting and purging. In 1760, Robert and Daniel Sutton were inoculating by puncture, discarding the depletory regimen for the more sensible strengthening of the patient by dietetic and hygienic means, and had some 30,000 cases, with about 4 per cent. mortality. Attenuation of the virus was attempted by passing it through several human subjects (Kirkpatrick's arm-to-arm method), by using very small quantities, by dilution with water, calomel, etc., or by choosing the virus at the crude or unripe stage. The author

[1] A remarkably complete bibliography of variolation, down to Jenner's time, and of vaccination (1798–1861) was printed (not published) by Dr. Ludwig Pfeiffer (of "Pestilentia in nummis") about 1863.

cites experiments which would stand comparison with those carried out in modern laboratories, especially those tabulated from William Watson's series of 1768, in which it is seen that Jenner did not initiate experimental research upon the subject but rather devised or followed lines already established before him. The most scientific worker in the field was Angelo Gatti of Pisa, who obtained permission to inoculate in Paris by the rational method of puncture and preparation in 1769. Gatti maintained that smallpox is always caused by the introduction into the body of a foreign body, which is in the nature of a specific virus in that it reproduces itself and multiplies, the disease being communicated by contact, inhalation or ingestion. He waxed furious against the senseless practise of weakening the patient by bleeding and purging, adopted Sutton's open-air and hydropathic régime, and offered prizes in real money for any authenticated case of reinfection after inoculation. Such cases he regarded as eruptions from a mixed infection of other exanthems, such as scarlatina or measles, which he also thought capable of transference by inoculation. The main difficulty with variolation was that each inoculated person was a possible "carrier" of the disease, and this occasioned Gatti and his associates considerable trouble in Paris. In the meantime, Tronchin, Tissot, Mead and other eminent physicians were influential in spreading the practise, which became a common preventive measure in America during the Revolutionary War. In 1768, Thomas Dimsdale was invited to St. Petersburg to inoculate Catherine the Great and her son, receiving for his trouble a barony, \$50,000 down, an annuity of \$2,500, \$10,000 for his expenses and handsome gifts of diamonds and furs. Jenner's experiments of 1796–8 soon swept variolation from the field, for the sufficient reason that there was little mortality and no possibility of transference of the disease by the vaccinated person. Variolation was declared a felony by Act of Parliament in 1840.

Dr. Klebs's memoir is well worthy of perusal by all who are interested in the history of preventive inoculation. Its permanent value is that it obviates the boresome necessity of investigating the huge literature of variolation, covering even the secular memoirs of eighteenth century celebrities. Its engaging style makes it eminently readable, revealing everywhere the spirit of its genial author.

F. H. Garrison

Army Medical Museum

A Primer on Alternating Currents. By W. G. Rhodes. Longmans, Green & Company. 1912. Pp. 145.

Although this book, according to the author, is primarily intended for students preparing for the alternating current part of the ordinary grade examination in electrical engineering of the city and guilds of London, it should be useful to those desiring a very brief elementary course on alternating currents and alternating current machinery. The book is primarily adapted to the use of evening classes in technical schools, and is written in such a way that no knowledge of mathematics is required beyond the elements of algebra. In order to avoid the necessity for the students in these classes to possess a multiplicity of books, such simple mathematical relations as are necessary for the development of the subject are proved in the first chapter of the book. For a similar reason, some useful constants and a short table of logarithms are given.

The early chapters of the book are devoted to developing the elementary principles of magnetism, induction and alternating currents. Alternating currents in circuits containing inductance and capacity are briefly considered. The rest of the book deals with transformers, synchronous motors, induction motors and rotary converters. In this part of the book use is made of simple vector diagrams. At the end of the book a few pages are given to the elementary principles underlying transmission of electrical energy and to simple power measurements. The usefulness of the book is increased by the addition of a number of examples with answers which are given at the end of each chapter.

This little book is well adapted for the purpose for which it is intended. One should expect to find in its 145 pages more than a most brief and elementary treatment of the

broad subject of alternating current and alternating current machinery.

Ralph R. Lawrence

Alternating Current Machinery. By Barr and Archibald. The Macmillan Company. 496 pages and 16 plates.

The title of this book is too broad and somewhat misleading as only certain types of alternating current machinery are considered, namely: the transformer, the alternator, and the rotary converter. No mention is made of induction machines or of the synchronous motor. The first chapters are devoted to complex wave forms and their analysis and to the properties of insulating materials used in alternating current machinery. The insulation of transformers and generators is also briefly considered. The remaining chapters deal with the theory and the design of the transformer, the alternator and the rotary converter. Three chapters are devoted to the transformer. Two of these are given up to the consideration of the fundamental principles, construction and vector diagrams, while the third is confined entirely to design. Some examples of different designs are included. Nine of the remaining twelve chapters deal with the alternator. The mechanical construction of alternators, different types of armature windings, harmonics caused by teeth, and the magnetic circuit are discussed in the first of these chapters. Several chapters are devoted to the discussion of armature reaction, voltage regulation and regulation tests. The effect of a sudden short circuit is also considered. The discussion of the losses, efficiency and heating of alternators is also given considerable space. One chapter is devoted to the parallel operation of alternators. The last chapter on alternators, a chapter of about forty pages, deals only with design. Several examples of design are given. The remaining three chapters are confined to the rotary converter and take up the transformation voltage ratio, armature reaction, armature heating and output. Voltage regulation, losses and efficiency, methods of starting and parallel working are discussed. The last chapter of the book deals entirely with the design of converters, and as in the other chapters on design, examples of the design of several converters are given. It is unfortunate that the author has used clockwise and anticlockwise directions of rotation indiscriminately on the vector diagrams to indicate a positive direction of rotation. Although an arrow is added to each vector diagram to indicate which direction of rotation has been adopted, the lack of a definite convention in this connection is apt to lead to confusion. The book is in general well arranged and should be a valuable one alike to the student and the engineer.

Ralph R. Lawrence

SCIENTIFIC JOURNALS AND ARTICLES

The opening (January) number of volume 16 of the *Transactions of the American Mathematical Society* contains the following papers:

G. M. Green: "On the theory of curved surfaces, and canonical systems in projective differential geometry."

H. S. White: "The multitude of triad systems on 31 letters."

G. A. Miller: "The Φ-subgroup of a group."

R. L. Moore: "On a set of postulates which suffice to define a number-plane."

W. C. Graustein: "The equivalence of complex points, planes, lines with respect to real motions and certain other groups of real transformations."

J. E. Rowe: "Invariants of the rational plane quintic curve and of any rational curve of odd order."

M. G. Gaba: "A set of postulates for general projective geometry."

Virgil Snyder and F. R. Sharpe: "Certain quartic surfaces belonging to infinite discontinuous cremonian groups."

Joseph Slepian: "The functions of a complex variable defined by an ordinary differential equation of the first order and the first degree."

Arthur Ranum: "On the differential geometry of ruled surfaces in 4-space and cyclic surfaces in 3-space."

The February number (Vol. 21, No. 5) of the *Bulletin of the American Mathematical Society* contains: Report of the eighth regular meeting of the Southwestern section, by O.

D. Kellogg; "Note on the potential and the antipotential group of a given group," by G. A. Miller; "The equation of Picard-Fuchs for an algebraic surface with arbitrary singularities," by S. Lefschetz; Review of Manning's Geometry of Four Dimensions, by J. L. Coolidge; "Shorter Notices"; Schröder's Entwicklung des mathematischen Unterrichts an den höheren Mädchenschulen Deutschlands, by E. B. Cowley; de Montessus and d'Adhémar's Calcul numérique and Dickson's Elementary Theory of Equations, by R. D. Carmichael; Smith's Teaching of Geometry and Smith and Mikami's History of Japanese Mathematics, by J. V. McKelvey; Study's Die realistische Weltansicht und die Lehre vom Raume and Jordan and Fiedler's Contribution à l'Etude des Courbes convexes fermées et de certaines Courbes qui s'y rattachent, by Arnold Emch; Mrs. Gifford's Natural Sines to Every Second of Arc, and Eight Places of Decimals, by D. E. Smith; Cobb's Applied Mathematics, by E. B. Lytle; von Sanden's Praktische Analysis and Hjelmslev's Darstellende Geometrie, by Virgil Snyder; "Notes"; and "New Publications."

THE March number of the *Bulletin* contains: Report of the twenty-first annual meeting of the society, by F. N. Cole; Report of the winter meeting of the society at Chicago, by H. E. Slaught; "The structure of the ether," by Harry Bateman; "Shorter Notices": Killing and Hovestadt's Handbuch des mathematischen Unterrichts, Band II, by D. D. Leib; Cahen's Théorie des Nombres, Tome premier, and Darboux's Théorie générale des Surfaces, première Partie, by T. H. Gronwall; "Notes"; and "New Publications."

SPECIAL ARTICLES

INTERPOLATION AS A MEANS OF APPROXIMATION TO THE GAMMA FUNCTION FOR HIGH VALUES OF n [1]

VARIOUS approximations to the value of $\Gamma(n)$ when n is large have been suggested by different workers and are in every-day use. In actual statistical practise the one which has appealed to the writer as most satisfactory, having regard to ease of calculation and degree of accuracy of result, is that of Forsyth,[2] which is

$$\Gamma(n+1) = \sqrt{2\pi}\left(\frac{\sqrt{n^2+n+\frac{1}{6}}}{e}\right)^{n+\frac{1}{2}}.$$

This is in error (in defect) in the proportion of $1/240n^3$.

It lately occurred to me that possibly a further saving of labor in computation, without loss of accuracy, could be made by interpolating in a table of log $|\underline{n}$ to get log $\Gamma(n)$. Tables of the sums of the logarithms of the natural numbers have recently been made readily available to statistical workers from different sources.[3] Such tables all proceed, of course, by integral steps of the argument n.

The question then is to determine what the order of magnitude of the error will be if one interpolates from such a table proceeding by integral steps, in order to determine $\Gamma(n)$. The relation

$$\Gamma(n+1) = |\underline{n} \qquad \text{(i)}$$

is exact when n is an integer. How great is the inequality when n is not integral but fairly large?

To test this matter I asked Mr. John Rice Miner, the staff computer of the laboratory, to carry through the computations for a short series of representative values of n. This he has done, with the results set forth in Table I., for which I am greatly obliged. It should be said that in all the computations seven-place logarithms only have been used. The first column, headed "exact value," gives the result obtained by using the value of log $\Gamma(x)$ for $x = 1.123$ from Legendre's tables, and then summing the logarithms up to $n-1$ for each desired value. This is the usual process, depending on the relation

[1] Papers from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 80.

[2] Forsyth, Brit. Assoc. Rept. for 1883, p. 47.

[3] *Cf.* Pearl and McPheters, *Amer. Nat.*, Vol. XLV., 1911, p. 756. More recently a longer table of sums of logarithms has been published in Pearson's "Tables for Statisticians and Biometricians," Cambridge, 1914.

$$\Gamma(n+1) = n\,\Gamma(n) = n(n-1)(n-2) \cdots (n-r)\,\Gamma(n-r). \quad \text{(ii)}$$

It becomes an exceedingly tedious operation when n has a value of over, say, 20. In calling this the "exact" value in the table the intention is merely to convey the idea that the only approximation involved is that incident upon the use of 7-place logarithms, the process *per se* being an exact one. The fourth and fifth columns of the table give the results obtained by using the values of log $\underline{|n}$, their first second and third differences, in the usual advancing difference interpolation formula

$$u_{x+n} = u_x + n\,\Delta u_x + {}_nC_2\,\Delta^2 u_x + {}_nC_3\,\Delta^3 u_x \cdots. \quad \text{(iii)}$$

TABLE I

Values of log Γ (n) by Different Methods

n	Exact Value	Forsyth's Approximation	Interpolation Using Δ^2	Interpolation Using Δ^3
5.123	1.4613860	1.4613679	1.4619138	1.4615069
15.123	11.0834931	11.0834916	11.0835559	11.0834985
25.123	23.9637108	23.9637096	23.9637336	23.9637119
35.123	38.6594135	38.6594126	38.6594251	38.6594138
75.133	107.7498704	107.7498692	107.7498727	107.7492870

From this table it is evident that the interpolation method, when third differences are used, gives values slightly better than those by Forsyth's method when $n \gtreqless 25$. For $n = 75$ or more the interpolation method using only second differences gives an approximation sufficiently close for all practical statistical purposes. As to the labor involved, there is no great amount of choice between Forsyth's and the interpolation method, but on the whole there appears to be a distinct, if small, advantage in favor of the interpolation.

RAYMOND PEARL

THE GEOLOGICAL SOCIETY OF AMERICA

THE twenty-seventh annual meeting of the Geological Society of America was held at the Academy of Natural Sciences, Philadelphia, December 29–31, 1914, under the presidency of Dr. George F. Becker, of the United States Geological Survey, Washington, D. C. On account of Dr. Becker's enforced absence through illness, the sessions were presided over by Vice-presidents Waldemar Lindgren and Horace B. Patton. In attendance there were registered 117 Fellows of the Society and the number of students and others, including members of the American Association for the Advancement of Science who were present at the sessions, swelled the attendance to more than 200, making this one of the most largely attended meetings in the history of the society.

At the first general session of the society Dr. Samuel G. Dixon, president of the Academy of Natural Sciences, welcomed the visiting geologists and paleontologists, making them feel very much at home as the guests of the historic academy.

The report of the council, as submitted in print, showed that the present enrollment of the society is 363, aside from the 19 new fellows elected at the meeting but who had not yet qualified. During the year 1914 the society lost five fellows by death: Alfred E. Barlow, Albert S. Bickmore, Horace C. Hovey, A. B. Wilmott and Newton H. Winchell; and three correspondents: H. Rosenbusch, Eduard Suess and Th. Tschernyschew. The treasurer's report showed that the society was in a flourishing condition financially and the editor's report indicated an unusual activity in publication during the past year.

The papers presented in the three general sessions of the society were as follows:

Relation of Bacteria to Deposition of Calcium Carbonate: KARL F. KELLERMAN.

At the suggestion of Dr. T. Wayland Vaughan, bacterial studies of water and bottom mud from the Great Salt Lake, and sea water and bottom deposits from the vicinity of Florida and the Bahamas were undertaken in the hope of supplementing the work of Vaughan,[1] of Drew[2] and of Dole[3] in regard to the probable agencies concerned in the precipitation of calcium carbonate and the formation of oolites.

It has been possible to form calcium carbonate by the action of bacteria on various soluble salts of calcium both in natural waters and in synthetic mixtures. The most important natural precipita-

[1] T. Wayland Vaughan, *Bull. Geol. Soc. Am.*, Vol. 25, No. 1, p. 59, March, 1914. Also Publication No. 182, Carnegie Inst. of Washington, pp. 49–67.

[2] G. H. Drew, Publication No. 182, Carnegie Inst. of Washington, pp. 49–67.

[3] R. B. Dole, Publication No. 182, Carnegie Inst. of Washington, pp. 69–78.

tion is probably the transformation of calcium carbonate by the combined action of ammonia, produced by bacteria either by the denitrification of nitrates or by the fermentation of protein, together with carbon dioxide, produced either by the respiration of large organisms or the fermentation of carbohydrates by bacteria. Both ordinary crystals of calcium carbonate and oolites may be produced by the growth of mixed cultures of bacteria, either in salt or fresh water. The zonal structure of the oolites of bacterial origin and of those found in nature in oolitic deposits appears to be exactly the same; undoubtedly this shows the similarity of the processes of their origin.

Coral Reefs and Reef Corals of the Southeastern United States, Their Geologic History and Their Significance: Thomas Wayland Vaughan.

After briefly alluding to some of the more recent publications on coral reefs, the author stated what in his opinion were the necessary lines of investigation in order to understand the ecologic factors influencing coral reef development, the constructional rôle of corals and other agents, and the series of geologic events which preceded any particular coral reef development. The geologic history of the extensive coral reefs of the southeastern United States and nearby West Indian islands, which have been the subject of investigation for a number of years, was outlined and the bearing they have on the theory of coral reef formation was indicated.

The author stated his conclusions regarding the Florida coral reefs as follows: (1) Corals have played a subordinate part, usually a negligible part, in the building of the Floridian plateau; (2) every conspicuous development of coral reefs or reef corals took place during subsidence; (3) in every instance the coral reefs or reef corals have developed on platform basements which owe their origin to geologic agencies other than those dependent on the presence of corals.

The older Tertiary reefs and reef corals of St. Bartholomew, Antigua and Anguilla all grew on subsiding basements. The relatively small proportion of the contribution by corals to calcareous sediments in Florida, the Bahamas and the West Indies was shown.

It was shown that the Floridian plateau was similar in configuration to the Mosquito Bank off Nicaragua, to Campeche Bank off Yucatan and to Georges Bank off Massachusetts; the east side of the Floridian plateau is similar to the continental shelf off Cape Hatteras. The platform which supports the reef along the east coast of Florida extends beyond the reef limits northward of Fowey Rock. The reef platform of the Great Barrier Reef of Australia is similar to the continental shelf of eastern North and Central America, and it continues south of the reef limits. Rosalind Bank, Caribbean Sea, was compared with Rangiroa, Paumotus, which is similar in essential features. The complex history of the coral reef foundations in Florida, Antigua, St. Martin, Anguilla and Bermuda was described, and it was stated that the formation of the platforms could not be referred solely to Pleistocene time.

Attention was directed to the facts that around the Island of Saba, in which volcanic activity has so recently ceased that the crater is still preserved, there was scarcely any platform at all; that in the case of the young but slightly older volcanic island of St. Kitts, the platform was narrow, while the geologically much older islands standing above the Antigua-Barbuda bank, the St. Martin plateau, and the Virgin Bank, rise above platforms which are miles across and have an area many times greater than that of the present land surfaces. Width of platform is therefore indicative not of the amount of submergence, but of the stages attained by planation processes.

The conclusions were summarized as follows:

1. Critical investigations of corals as constructional geologic agents are bringing constantly increasing proof that they are not so important as was long believed, and that many of the phenomena formerly attributed to them must be accounted for by other agencies. Here it should be emphasized that the ecology of probably no other group of marine organisms is known nearly so thoroughly as that of corals.

2. All known modern off-shore reefs which have been investigated grow on platforms which have been submerged in recent geologic time.

3. No evidence has as yet been presented to show that any barrier reef began to form as a fringing reef on a sloping shore and was converted into a barrier by subsidence; but it is clear that many, if not all barrier reefs stand on marginal platforms which already existed previous to recent submergence and the formation of the modern reefs.

4. Study of the geologic history of coral reef platforms has established that there were platforms in early Tertiary time on the site of many of the present-day platforms, and evidence has not as yet been adduced to prove long-continued, uninterrupted subsidence in any coral reef area. There have been many oscillations of sea level and recent submergence is probably complicated in many

areas by differential crustal movement concomitant with increase in volume of oceanic water through deglaciation.

5. The width of a submerged platform bordering a land area is indicative not of the amount of submergence, but of the stage attained by planation processes. Other conditions being similar, the longer the period of activity of such processes the wider will be the platform.

6. The principal value of the coral reef investigation to geology consists not so much in what has been found out about corals as in the study of a complex of geologic phenomena, among which coral reefs are only a conspicuous incident.

Causes Producing Scratched, Impressed, Fractured and Recemented Pebbles in Ancient Conglomerates: JOHN M. CLARKE.

The Devonian conglomerate lying beneath the fish-beds of Migonasha, P. Q., is a characteristic "Nagelfluh" filled with scratched, fractured and deeply impressed pebbles. Specimens exhibited indicate that the explanation of the phenomena of impression by solution, as suggested by Sorby, Heim, Kayser and others, is inadequate and that the effects described are in large part actually due to forcible contact resulting from internal friction. Some of the pebbles show unqualified evidence of glacial scratching and the entire mass is regarded as an outwash from glacial moraine.

Revision of Pre-Cambrian Classification in Ontario: WILLET G. MILLER AND CYRIL W. KNIGHT.

During the past decade the authors have been engaged in detailed work on pre-Cambrian areas in various parts of the Province of Ontario. The results of this work, and that of other investigators, have made apparent the necessity for revising the age classification of the pre-Cambrian rocks, particularly in the use of the terms Huronian, Laurentian and others. The following classification and nomenclature have therefore been adopted by the Ontario Bureau of Mines.

KEWEENAWAN.

Unconformity.

ANIMIKEAN.

Under this heading the authors place not only the rocks that have heretofore been called Animikie, but the so-called Huronian rocks of the "classic" Lake Huron area, and the Cobalt and Ramsay Lake series. Minor unconformities occur within the Animikean.

Great Unconformity.

(ALGOMAN GRANITE AND GNEISS.)

Laurentian of some authors, and the Lorrain granite of Cobalt, and the Killarney granite of Lake Huron, etc.

Igneous Contact.

TIMISKAMIAN.

In this group the authors place sedimentary rocks of various localities that heretofore have been called Huronian, and the Sudbury series of Coleman.

Great Unconformity.

There is no evidence that this unconformity is of lesser magnitude than that beneath the Animikean.

(LAURENTIAN GRANITE AND GNEISS.)

Igneous Contact.

LOGANIAN.

Grenville (*Sedimentary*), Keewatin (*Igneous*).

The authors have found the Keewatin to occur in considerable volume in S. E. Ontario and have determined the relations of the Grenville to it.

Investigations by the junior author during 1914 have shown that certain rocks of the "classic" Huronian area of Lake Huron, the "Thessalon greenstones," that heretofore have been placed with the Keewatin, are of much later age, being in intrusive contact with the Animikean, as defined in the above table.

North American Continent in Upper Devonic Time: AMADEUS W. GRABAU.

The history of North America in the Upper Devonic has been worked out in some detail, on the basis of physical stratigraphy combined with paleontology.

At the opening of the Upper Devonic, marine waters were much restricted in North America, the greater part of the United States being exposed to active erosion of the previously deposited Hamilton or earlier formations, as indicated by disconformities. The Tully-Genesee sea was restricted to central New York, but extended northward over Canada. Appalachia, Atlantica (the Old Red Continent) and Mississippia were the chief continents. The evidence pointing to the gradual southward transgression of the sea over the eroded lands is clear. Three open marine water bodies existed throughout Upper Devonic time, each with its Urals, (2) the western or North Pacific, extending from central New York across Ellsmere land to the Urals, (2) the western or North Pacific extending across part of Alaska, (3) the eastern or Atlantic. The latter entered the interior by way of a narrow strait between Appalachia and Atlantica, permitting the periodic invasion of the Atlantic or Tropidoleptus fauna. There may have been a fourth South Pacific water body extending into Nevada, but this is less certain. Three principal river systems are recognized in the lowland of Mississippia. These have furnished the black mud for the black shales which were deposited in embayments of di-

minished salinity. The eastern or Genesee beds are restricted to New York and the states just south. The base of the black shale of Ohio, Michigan and Canada is younger than Genesee, as shown by stratigraphic and paleontologic evidence. The great fish fauna of these shales is shown by its occurrence and distribution to be primarily the fauna of these sluggish rivers projected at intervals into the brackish water of the embayments. The land flora of Mississippia is also preserved in these shales. The rivers of Appalachia and Atlantica also had their fish fauna, but these were of different types, their smaller size adapting them to these torrential streams. With them occurred the survivors of the Eurypterids, which also inhabited the rivers of the Paleozoic lands. The flora of Appalachia and Atlantica is likewise largely distinct from that of Mississippia. The deposits made by these rivers were partly preserved as sandy deltas and alluvial fans.

"Symposium on the Passage from the Jurassic to the Cretaceous."

(1) *The Morrison; An Initial Cretaceous Formation:* Willis T. Lee.

(2) *Origin and Distribution of the Morrison:* Charles C. Mook.

(3) *Sauropoda and Stegosauria of the Morrison Compared with those of South America, England and Eastern Africa:* R. S. Lull.

(4) *The Paleobotanic Evidence:* E. W. Berry.

(5) *The Invertebrate Fauna of the Morrison:* T. W. Stanton.

Present Condition of the Volcanoes of Southern Italy: H. S. Washington and A. L. Day.

A brief description of the general condition and state of activity at Vesuvius, Etna, Vulcano and Stromboli, as observed during the summer of 1914.

Recent Eruptions of Lassen Peak, California: J. S. Diller.

Lassen Peak, in northeastern California, at the southern end of the Cascade Range, has long been considered an extinct volcano, but has recently shown signs of rejuvenescence. The first of the recent outbreaks occurred at 5 P.M., May 30, 1914, and since then many eruptions have occurred. The nature of this remarkable phenomenon was illustrated and discussed.

Physiographic Study of the Cretaceous-Eocene Period in the Rocky Mountain Front and Great Plain Provinces: George H. Ashley.

The study of the rocks, especially of the coal beds, the structure and the life in the provinces named, appears to indicate that Upper Cretaceous time in that region was occupied by a single movement of subsidence, somewhat irregular, but, on the whole, persistent: that this was followed by a period of general and differential uplift, to be followed in turn by renewed subsidence, interrupted locally, from time to time, by pronounced movements of differential uplift. Comparison is made between this interpretation and the assumed conditions in the eastern United States and certain deductions drawn as to the point in the time scale at which the first general uplift occurred.

Relation of Physiographic Changes to Ore Alterations: Wallace W. Atwood.

While a land mass is being dissected, the groundwater table is slowly lowered through that mass, until, at the peneplain and base-level stages, the groundwater table remains almost stationary for long periods of time. During successive cycles of erosion the position of the base-level of erosion in the land mass being dissected must change, and, if climatic conditions remain constant, such changes are necessarily accompanied by changes in the position of the groundwater table. If the land mass is elevated, the base-level will be lowered through the land, and the groundwater table will be slowly lowered. When a land mass is depressed, the base-level of erosion and the groundwater table are elevated throughout that land mass. Moist climates will raise the groundwater table, and dry periods lower that table. As the groundwater table is raised or lowered, the zones in which the chemical changes associated with the secondary alteration of ore deposits take place are varied in thickness.

These facts indicate that physiographic studies may be profitably applied in the study of ore alterations, and conversely that the record of ore alterations may furnish important data bearing upon the physiographic evolution of the districts concerned.

The study of secondary ores by various investigators has called for intensive physiographic studies. During the past season field work was done in the vicinity of Butte, Montana, and Bingham Canyon, Utah, to determine the relationship of physiographic evolution to the secondary enrichment of ores in those regions. In this paper the problem of the application of physiography to the investigation of secondary ores was defined, and some of the results of the past season's field work were presented.

Graphic Projection of Pleistocene Climatic Oscillations: Chester A. Reeds.

Penck's curve, page 1168, "Die Alpen im Eiszeitalter," 1909, expresses graphically the climatic oscillations of the alpine district for Pleistocene and post-Pleistocene time. The key to the four glaciations and the three interglacial stages indicated in the curve was found in the four outwash deposits of glacio-fluvial streams on the northern foreland of the Alps in the vicinity of Ulm and Munich. Along the present stream valleys the glacio-fluvial deposits are arranged in terraces, the oldest occupying the highest position and the youngest the lowest level. When the key was carried in mind to the French and Italian Alps the remarkable association of these deposits on the northern foreland was found to be applicable throughout. Hence the names of four small tributaries of the Danube which cross the outwash deposits on the Bavarian plateau, Günz, Mindel, Riss and Würm, were applied by Penck and Brückner to the first, second, third and fourth glaciations. The deposits of the third or Riss glaciation in the Swiss and French Jura extend farther out on the foreland than the deposits of the other glacial advances, but in other districts the morainal deposits of the second or Mindel stage extend beyond that of any other, hence it is regarded as the most extensive of the four alpine glaciations. The morainal and outwash deposits of the first or Günz glaciation are least in evidence while those of the fourth or Würm glaciation, the last, are most in evidence.

That the temperature of the alpine region was considerably colder during the stages of glaciation than during the interglacial stages and the present which is at the close of the retreating hemicycle of the last glaciation, is shown conclusively by the depressed snow lines. Penck has determined their position in the Alps for all four glaciations. They have a distribution parallel to that of the present snow-line, but occupying lower levels, namely, Günz, 1,200 meters, Mindel, 1,350 meters, Riss, 1,300 meters, and Würm, 1,200 meters below the present snow-line. During the interglacial stages the snow-line was approximately 300 meters higher than the present one. From the Höttinger Breccia near Innsbruck Penck determined that there was a temperature variation of 1° C. for every 200-meter change in the altitude of the snow-line.

The unit of measurement which Penck used in estimating the duration of the Pleistocene period is the retreating hemicycle of glaciation of the fourth or Würm stage, better known as the post-glacial period. In the alpine district Penck and Brückner found that in this retreating hemicycle there were three minor advances called the Bühl, Gschnitz and Daun stadia. These advances were preceded by a prominent minor retreat of the Achen oscillation. From the lignite deposits of Dürnten, the deposits of the Muota deltas and the turf deposits in many of the glacial swamps it has been possible to estimate the duration of this hemicycle of glaciation in years, as follows:

Subdivisions of Post-Glacial Time

	Years
Achen oscillation	9,000
Bühl advance and retreat	5,000
Gschnitz advance and retreat	4,000
Daun advance and retreat	3,000
Age of copper	1,000
Post-copper time	3,000
Total	25,000

The estimate on the duration of post-glacial time in America is based chiefly on the recession of the waterfalls of Niagara and St. Anthony. Recently Coleman[4] made an estimate based on the rate of wave erosion on the shore of Lake Ontario and glacial Lake Iroquois. Twenty-five thousand years is a figure which falls within the estimates made by Coleman, Taylor, Lyell, Chamberlain and Salisbury. It is a bit under those of Fairchild, Sardeson and Spencer and above those of Gilbert and Upham. It is considered a conservative figure.

Penck states that it must have been 16,000 to 24,000 years from the Bühl stadium to the present, with 20,000 years as an average, and 25,000 to 40,000 years from the beginning of the Achen retreat to the present. In selecting a figure, however, which shall be used as a unit of measurement in calculating the duration of the entire Pleistocene period, he chooses 20,000 years as the length of post-Würm time.

The correlation of the mountain glaciations of the Alps with those of the Scandinavian continental ice fields of Pleistocene time has not been worked out in all regions, but there is sufficient information at hand to say that there were four advances of the continental ice over northern Europe which correspond to the periods of ice advance upon the alpine forelands. Geikie remapped in 1914 the second, third and fourth glaciation distribution in Europe. G. de Geer delimited the retreating stages of the fourth glaciation in the Scandinavian peninsula in 1912.

A correlation of American with European glacial deposits has been made by Leverett. By consid-

[4] Coleman, A. P., Proceedings, Twelfth Inter. Geol. Cong., Canada, 1913.

ering with Leverett[5] the so-called Iowan glaciation contemporaneous with the Illinoian it is possible to correlate the Günz glaciation with the Nebraskan, the Kansan with the Mindel, the Illinoian with the Riss and the Wisconsin, early and late, with the Würm. There are corresponding interglacial stages. With the time units of Chamberlain and Salisbury[6] 2, 4, 8, 16, in mind for the duration of the last three glaciations, based upon the degree of weathering of American glacial deposits, it is possible to construct a curve similar to Penck's, but differing in length and the number of units assigned to the interglacial stages. In tabular form the data appear thus:

Estimated Duration of Pleistocene Oscillations

	Reeds, 1914			Penck, 1909		
	Units	Years	Totals	Units	Years	Totals
Post-glacial....	1	25,000	25,000	1	20,000	20,000
Fourth glacial..	1	25,000	50,000	1	20,000	40,000
Third interglacial..........	4	100,000	150,000	3	60,000	100,000
Third glacial...	1	25,000	175,000	1	20,000	120,000
Second interglacial..........	8	200,000	375,000	12	240,000	360,000
Second glacial..	1	25,000	400,000	1	20,000	380,000
First interglacial	3	75,000	475,000	5	100,000	480,000
First glacial....	1	25,000	500,000	1	20,000	500,000
Pre-transitional.	1	25,000	525,000	1	20,000	520,000

Geologic Deposits in Relation to Pleistocene Man: CHESTER A. REEDS.

The present known distribution of Pleistocene man through southern Europe, the Mediterranean border and Java, points to the conclusion that this early man lived along the river courses, on the adjacent uplands, in caves and grottoes which overlooked well-defined river valleys and on the seashore. Human remains have been found entombed in a few caves within the region of mountain glaciation—for example, Frendenthal, Kesslerlock and Schweizersbild in Switzerland—but most of the finds have been made in the southern nonglaciated portions of Europe. The vicissitudes and the ameliorations of climate during the glacial and interglacial stages no doubt caused southward or northward migrations of peoples or encouraged congestion in the limestone caverns of Belgium, France, Germany and northern Spain. With the repeated formation of continental ice sheets on the Scandinavian plateau during periods of glaciation and their movement outward in all directions across the adjacent basins and lowlands of northern Europe, together with the appearance of ice caps on the high mountains of southern Europe, the lowering of the snow line on the mountain slopes, the development of snow caps on plateaus of but moderate relief, the extension of the glaciers into aprons and tongues on the piedmont areas and the choking of the river valleys with ice and deposits, glacial man must have felt that Snow and Ice were the governing forces. The warmer interglacial epochs were more to his liking. In the present terrace and loess deposits along the river courses and in the cave and grotto fillings, eight human culture stages have been delimited within recent years. They have been called, beginning at the bottom, pre-Chellean, Chellean, Acheulean and Mousterian as Lower Paleolithic and Aurignacian, Solutrean, Magdalenian and Azylian-Tardenoisan as Upper Paleolithic. In the cavern and grotto deposits of the Dordogne, southern France, most of the culture stages appear in regular geologic sequence one above the other. Human remains and culture stations of glacial, interglacial or post-glacial age have been found in approximately three hundred different localities.

[5] Leverett, F., *Zeitschrift für Gletscherkunde*, Vol. IV., pp. 282–83, 1910.

[6] Chamberlain and Salisbury, "Text-Book of Geology," Vol. III., p. 414, 1906.

Physiographic Features of Western Europe as a Factor in the War: DOUGLAS W. JOHNSON.

Every military campaign is controlled to some extent by the surface features of the country over which the contending armies must move. The physiography of a region may therefore profoundly affect both the detailed movements of armies and the general plans of campaign. An examination of the physiographic features of western Europe in the light of recent events enables one to comprehend more fully the strategic importance of many places mentioned in war dispatches and throws valuable light upon the question as to why the neutrality of Belgium was violated.

John Boyd Thacher Park. The Helderberg Escarpment as a Geological Park: GEORGE F. KUNZ.

A most important benefaction to the state of New York is the beautiful John Boyd Thacher Park, opened with appropriate ceremonies September 14, 1914. During the winter of 1913–14 the American Scenic and Historic Preservation Society received word of the intention of Mrs. Thacher, widow of John Boyd Thacher, to realize her generous purpose of donating to the state a superb trust of 350 acres of land for a public park,

as a memorial of her husband, and in March, 1914, a bill was introduced and passed in the legislature accepting the gift and constituting the American Scenic and Historic Preservation Society the custodian. The park embraces the most picturesque and geologically interesting part of the Helderberg range in Albany County.

The remarkable geologic formations to be seen in this park include one of the finest exposures of the Upper Silurian and Devonian strata in the country, and offer classic types of several formations, as is shown by the designations "Helderberg limestone" and "Helderberg group"; the rocks contain a great number of characteristic fossils, especially of marine forms. On the slope appear Hudson shales, and flaggy sandstones of the Hamilton formation crown Countryman Hill. The deep amphitheater at Indian Ladder has been worn out by the water of a small stream.

There is now a small museum and library in the park, and the Geological Survey has set up a bench-mark. It is hoped that very soon the cottage-building for the reception of guests will be completed, so as to afford comfortable shelter for visiting geologists who wish to study this Mecca of geologists. The library would be glad to receive geological publications having any bearing on the local conditions; such mail should be addressed to the curator of John Boyd Thacher Park, East Berne, New York. (By title only.)

The Relief of our Pacific Coast: J. S. DILLER.

The continental feature bordering the Pacific coast of the United States is a mountain belt of surpassing grandeur and composed in general of two lines or ranges of mountain elevations with a depression between. For the most part the two lines of mountains appear to be parallel with each other and the coast, the Sierra Nevada and the Cascade Ranges on the east and the Coast Ranges, including the Klamath Mountains of California and Oregon and the Olympic Mountains of Washington on the west, from the Mexican line to that of British Columbia. Cross folds connect the side ranges and separate the great valley of California from the Willamette Valley of Oregon.

The Sierra Nevada is composed of folded sediments and igneous rocks of various ages from Silurian to Jurassic, and faulted and tilted as one great block with long gentle slope to the west and steep slope to the east.

The Cascade Range is essentially volcanic and due mainly to volcanic upbuilding, though partly to uplifting, from Mount Adams in Washington to Lassen Peak in California, but beyond these limits the older crystalline rocks rise to the surface.

The Klamath Mountains are in large measure like the Sierra Nevada in their rocks, although more fossiliferous, but differ in structure, being characterized by broadly curved thrust faults with the overthrust into the concave curve and thus toward the Pacific ocean.

The coast ranges of California and Oregon are composed almost wholly of Mesozoic and Tertiary rocks. In California the coast range rocks are greatly crushed and faulted, but in Oregon the compression has been much less intense.

At eight o'clock P.M., on December 29, the society convened in the lecture hall of the Academy of Natural Sciences and listened to the reading by Vice-president W. Lindgren of an abstract of the address of the retiring president, George F. Becker. The title of his address was "Isostasy and Radioactivity."

In addition to the papers which were read at the general sessions, the following papers were presented in the sectional meetings of the society:

"Origin of the Red Beds of Western Wyoming," by E. B. Branson.

"Some New Points on the Origin of Dolomites," by Francis M. Van Tuyl.

"Range and Rhythmic Action of Sand-Blast Erosion, from Studies in the Libyan Desert," by William H. Hobbs (by title).

"Corrasive Efficiency of Natural Sand-Blast," by Charles Keyes (by title).

"False Fault-Scarps of Desert Ranges," by Charles Keyes (by title).

"Stratigraphic Disturbance Through the Ohio Valley Running from the Appalachian Plateau in Pennsylvania to the Ozark Mountains in Missouri," by James H. Gardner (by title).

"Preliminary Paper on Recent Crustal Movements in the Lake Erie Region," by Charles E. Decker.

"Quaternary Deformation in Southern Illinois and Southeastern Missouri," by Eugene Wesley Shaw (by title).

"Old Shorelines of Mackinac Island and their Relations to the Lake History," by Frank B. Taylor.

"Some Peculiarities of Glacial Erosion Near the Margin of the Continental Glacier in Central Illinois," by John L. Rich.

"New Evidence for the Existence of Fixed Anticyclones above Continental Glaciers," by William Herbert Hobbs (by title).

"Can U-shaped Valleys be Produced by Removal of Talus?" by Alfred C. Lane (by title).

"On the Origin of Monk's Mound," by A. R. Crook.

"Physiographic Studies in the Driftless Area," by Arthur C. Trowbridge (by title).

"Hemicones at the Mouths of Hanging Valleys," by Charles E. Decker (by title).

"Block Diagrams of State Physiography," by A. K. Lobeck (by title).

"Pre-Cambrian Igneous Rocks of the Pennsylvania Piedmont," by F. Bascom (by title).

"Magmatic Assimilation," by F. Bascom (by title).

"Hypersthene Syenite (Akerite) of the Middle and Northern Blue Ridge Region, Virginia," by Thomas L. Watson and Justus H. Cline (by title).

"Pyrrhotite, Norite and Pyroxenite from Litchfield, Connecticut," by Ernest Howe.

"Some Effects of Pressure on Rocks and Minerals," by John Johnston.

"Primary Chalcocite in the Fluorspar Veins of Jefferson County, Colorado," by Horace B. Patton.

"Recent Remarkable Gold 'Strike' at the Cresson Mine, Cripple Creek, Colorado," by Horace B. Patton.

"Platinum-gold Lode Deposit in Southern Nevada," by Adolph Knopf.

"Organic Origin of Some Mineral Deposits in Unaltered Paleozoic Sediments," by Gilbert van Ingen.

"Type of Rifted Relict Mountain, or Rift-Mountain," by John M. Clarke.

"Evidence of Recent Subsidence on the Coast of Maine," by Charles A. Davis.

"Basic Rocks of Rhode Island: Their Correlation and Relationships," by A. C. Hawkins and C. W. Brown.

"Acadian Triassic," by Sidney Powers.

"Geological History of the Bay of Fundy," by Sidney Powers.

"Alexandrian Rocks of Northeastern Illinois and Eastern Wisconsin," by T. E. Savage.

"Olentangy Shale and Associated Deposits of Northern Ohio," by Clinton R. Stauffer (by title).

"Diastrophic Importance of the Unconformity at the base of the Berea Sandstone in Ohio," by H. P. Cushing.

"Kinderhookian Age of the Chattanoogan Series," by E. O. Ulrich.

"Origin of the Iron Ores at Kiruna, Sweden," by Reginald R. Daly (by title).

"Origin of the Rocky Mountain Phosphate Deposits—Preliminary Statement," by Eliot Blackwelder (by title).

"Regional Alteration of Oil Shales," by David White (by title).

"Oil Pools of Southern Oklahoma and Northern Texas," by James H. Gardner.

"Natural Gas at Cleveland, Ohio," by Frank R. Van Horn.

"Origin of Thick Salt and Gypsum Deposits," by E. B. Branson.

"Crystalline Marbles of Alabama," by Wm. F. Prouty (by title).

"Devonian of Central Missouri," by E. B. Branson and D. K. Greger.

"Olentangy Shale of Central Ohio and its Stratigraphic Significance," by Amadeus W. Grabau.

"Hamilton Group of Western New York," by Amadeus W. Grabau.

"Extension of Morrison Formation into New Mexico," by N. H. Darton (by title).

"Geological Reconnaissance of Porto Rico," by Charles P. Berkey.

"Relation of Cretaceous Formations to the Rocky Mountains in Colorado and New Mexico," by Willis T. Lee.

"Post-Ordovician Deformation in the St. Lawrence Valley, N. Y." by George H. Chadwick.

The annual dinner of the society was held on the evening of December 30 and was attended by 140 of the members of the society and their friends. E. O. Hovey acted as toastmaster and the speakers of the evening were Messrs. W. Lindgren, H. F. Osborn, C. D. Walcott, C. R. Van Hise, W. W. Atwood and F. R. Van Horn.

In addition to the hospitality offered by the Academy of Natural Sciences, the Fellows of the society resident in Philadelphia entertained the Geological and Paleontological Societies and their friends at luncheon each day of the meeting and at a smoker given on the evening of the first day, at the close of the reading of the presidential address.

The officers elected for the year 1915 were Arthur P. Coleman, president; L. V. Pirsson, first vice-president; H. P. Cushing, second vice-president; Edward O. Ulrich, third vice-president; Edmund Otis Hovey, secretary; Wm. Bullock Clark, treasurer; J. Stanley-Brown, editor, and Frank R. Van Horn, librarian.

The next meeting of the society will be held at Washington, D. C., December 28–30, 1915.

EDMUND OTIS HOVEY,
Secretary